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ANNUAL REPORTS

OF THE

WAR DEPARTMENT

116299

FOR THE

V. 3

FISCAL YEAR ENDED JUNE 30, 1897.

REPORT OF THE

CHIEF OF ORDNANCE.

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REPORT OF THE CHIEF OF ORDNANCE.

WAR DEPARTMENT, ORDNANCE OFFICE,
Washington, October 1, 1897.

SIR: I have the honor to submit the following report of the principal operations of the Ordnance Department during the fiscal year ended June 30, 1897, with such remarks and recommendations as the interests of this branch of the military service seem to require.

The fiscal resources and expenditures of the Department during the year were as follows, viz:

Amount in the Treasury to the credit of the appropriations on June 30, 1896	$1,790,096.86
Amount in the Treasury not reported to the credit of the appropriations on June 30, 1896	747.42
Amount in Government depositories to the credit of disbursing officers and others on June 30, 1896	425,003.77
Amount of appropriations for the service of the fiscal year ended June 30, 1897, including the appropriation for armament of fortifications in the act approved March 3, 1897	a10,207,378.13
Amounts refunded to ordnance appropriations in settling accounts during the fiscal year ended June 30, 1897	308,942.68
Gross amount received during the fiscal year ended June 30, 1897, from sales to officers, from rents, from collections from troops on account of losses of or damage to ordnance stores, from Chicago, Rock Island and Pacific Railroad Company, from powder and projectiles (proceeds of sales), from sales of condemned stores, from testing machine, and from all other sources not before mentioned	120,672.61
Total	12,852,841.47
Amount of expenditures during the fiscal year ended June 30, 1897, including expenses attending sales of condemned stores, exchange of powder, etc	4,901,108.55
Amount deposited in Treasury during the fiscal year ended June 30, 1897, as proceeds of sales of Government property	54,790.94
Amount turned into the surplus fund on June 30, 1897	1,574.29
Amount in Government depositories to the credit of disbursing officers and others on June 30, 1897	614,266.50
Amount transferred from ordnance appropriations in settling accounts during the fiscal year ended June 30, 1897	66,894.93
Amount in the Treasury not reported to the credit of appropriations on June 30, 1897	340.52
Amount in the Treasury to the credit of appropriations on June 30, 1897	7,213,865.74
Total	12,852,841.47

a The appropriations for the Ordnance Department in the act approved March 3, 1897, are included in this amount.

ARMING THE MILITIA.

The act of Congress approved February 24, 1897, provides—

That the Secretary of War is hereby authorized to issue to the governors of the several States and Territories such number of Springfield breech-loading rifles, caliber forty-five one-hundredths of an inch, as are now required for arming all of the regularly organized armed and equipped militia (generally known as the National Guard) of each State and Territory that are not already supplied with this arm: *Provided*, That each State or Territory be required on receipt of the new arms to turn into the Ordnance Department, United States Army (without receiving any money credit therefor), an equal number of the arms now in its possession, except its Springfield rifles, caliber forty-five one-hundredths of an inch.

Under the authority of the above-cited law, 24,564 Springfield rifles, caliber .45, and 591 Springfield carbines, caliber .45, have been issued to the following States, viz:

To—	Rifles.	Carbines.	To—	Rifles.	Carbines.
Arkansas	94	50	Ohio	3,000	
Connecticut	1,834		Oregon		101
Georgia	1,138		South Carolina	660	
Iowa	440		South Dakota	90	
Louisiana	762		Tennessee	140	
Maine	150		Virginia	659	
Nebraska	737		Wisconsin	1,600	
Nevada	200				
New York	13,060	440	Total	24,564	591

The third section of the act of February 24, 1897, referred to above, reads as follows, viz:

SEC. 3. That any State or Territory may, in addition to the stores and supplies issued under the provisions of this act and the act of February, eighteen hundred and eighty-seven, purchase for the use of its national guard or reserve militia, at regulation prices for cash at place of sale, such stores and supplies from any department of the Army as, in the opinion of the Secretary of War, can be spared.

Attention is invited to the fact that while this law authorizes sales to the militia from the ordnance and ordnance stores procured for the Army, it makes no provision for using the proceeds of the sales in replenishing the supplies taken from the Army.

The ordnance and ordnance stores procured for the Army under the appropriations made by Congress are barely sufficient for this purpose, and none of them can be spared for sales to the States unless they are replaced. This fact makes this provision of the act practically inoperative.

With the view of enabling the several States and Territories to avail themselves of the above quoted very desirable and important provision of law enacted by Congress, I recommend that Congress be requested to amend the act of February 24, 1897, by adding the following words, viz:

And hereafter the cost of stores and supplies sold to any State or Territory under section 3 of the act approved February 24, 1897, shall be credited to the appropriation from which they were procured, and remain available to procure like stores and supplies for the Army.

This simply provides for replacing the stores.

During the past summer one of the States desired to purchase for the further equipment of its militia ordnance and ordnance stores in value about $25,000, but owing to the limitations in scope of this law the sale could not be recommended.

In accordance with the requirements of the act of Congress approved March 2, 1895 (vol. 28, p. 808, Stat. L.), I have the honor to report as follows:

The clerical force in this office provided for and adapted to correspondence is barely sufficient, with the utmost endeavors to minimize the same, for the amount of such work required for what has heretofore been the regular business of the office. In addition to such ordinary business there has recently been an extraordinary increase of this labor, due to the difficult and extensive correspondence growing out of the numerous large contracts, purchases, inspections, settlement of designs, drawings, and specifications, requirements, and controversies in connection with the large purchases of forgings, guns, carriages, projectiles, powders, etc., for the coast defense. The nature of this work (being correspondence) is such that it must be kept up to date each day, and to accomplish this it has been necessary to take important clerks from their regular duties and clerks not well adapted to this duty. In consequence of this the examination of property accounts from the Army is about three months behind, and unless some relief can be obtained it appears that other necessary work can not be kept up to date. I have, therefore, in the estimates submitted this year, asked for two additional expert stenographers and typewriters, at $1,000 per year each. With these it is believed the files can be kept up as long as the additional work now devolved upon this office shall last.

ROCK ISLAND ARSENAL.

ROCK ISLAND ARSENAL WATER POWER.

The extraordinary repairs of the dikes and dams of the Rock Island water power have been carried on during the year. In general, the openings in the upper end of the Moline dam wall are closed, and the whole water-power privilege, used and unused by the Moline Water Power Company, has been concentrated near the east end of Sylvan Island, a new concrete dam with openings being constructed for this purpose at that point. The wall in which the openings have been closed is now a revetment wall, which will be backed by a retaining embankment, which embankment will be carried to a height above the wall, which will render it safe against the most extreme floods heretofore recorded. This embankment also strengthens the wall to such an extent that it is believed that the necessity for extensive repairs should not arise for many years. Moreover, the material for the embankment being taken from the water-power pool will afford considerable improvement to the water power itself.

The appropriation for the repairs of the water power for strengthening this old Moline wall, made in the appropriation act for sundry civil purposes, etc., approved March 2, 1895, was reported to be sufficient for the completion of the whole work, including the strengthening of this old wall. In January, 1897, the commanding officer of the arsenal first reported to me that the appropriation was exhausted, and this work of strengthening the Moline wall had not been done. The changes in the water power, mentioned above, whereby a new dam for the greater efficiency of the Moline Water Power Company's power had been constructed near the lower or western end of that company's old tailrace (along the back of the Moline wall and stone dike in continuation of the same), cut off the outlet of water from this old tailrace. In times of extreme high water, or more properly at the freshet stages of the river, water has run over the whole length (about 2,200 feet) of this old Moline dam. So long as the lower end of the tailrace was open to the canal and to the river below this overflow caused no damage. As the new construction cut off this outlet at the lower end, the embankment behind the dam to strengthen it was to be raised above the highest freshet stages of the river, and thereby prevent this overflow. As the freshet stage is liable to occur usually about June, it was necessary that this embankment should be built as early as possible last spring. Otherwise the water might flow over the wall, and the outlet at the lower end being cut off, the old tailrace would be filled up, would flood the extensive and valuable shops of the city of Moline along the back shore of the tailrace, and the water having to find an outlet through these shops to the city back of the shops, might cause extensive damage.

On this account the matter was reported to Congress in much haste and an appropriation asked for for the construction of the embankment at once. It was expected that this appropriation would be obtained in time to do the work as soon as the ice was out of the river in the spring, in order that it might be completed before the anticipated rise of the river. The appropriation was included in the sundry civil bill and this bill was not finally passed until June 4, 1897. In the meantime the river reached the freshet stage in May—much earlier than it usually occurs. In consequence of this, grave apprehensions of the danger to the shops and city of Moline, mentioned above, arose. At your request I went to Rock Island Arsenal to see what could be done. I found on my arrival that the new commanding officer—Capt. S. E. Blunt—who had been at the arsenal but a few days, had, as I hoped, perfected plans to provide for the outflow of the water at the lower end of the tailrace in case the apprehended freshet should occur. These plans were carried out and would, in my opinion, have furnished ample protection from the danger apprehended. The water, however, rose to but a few inches above the wall, and serious difficulty was not encountered.

This permitted a postponement of the work until the very favorable season of extreme low water this fall. The work is now in progress.

BRIDGES.

The Rock Island wagon bridge and the Moline bridge have been painted, and the Moline bridge has had the wood floor renewed; also the old floor stringers, which were much decayed, were replaced by new ones, some of wrought-iron beams and some of wood. The traffic from January 1, 1897, to June 30, 1897, over the bridge to Davenport has been very extensive.

It is possible that some minor details of the draw mechanism of the bridge to Davenport may have to be strengthened or further adjusted, but work will not be necessary before the close of navigation. The painting will have to be renewed, and an estimate for this work is submitted. An estimate is also submitted for the new floor stringers and planking required for the Rock Island wagon bridge. These have not been replaced for several years, and have reached a condition where a thorough overhauling should be made.

An estimate is also submitted for repairs to the arsenal railroad. The ties are now badly decayed, and the road can only be used with extreme care. The roadbed itself will have to be carefully gone over and a majority of the ties replaced.

NEW BUILDINGS.

The buildings which have been used for many years as post hospital and upper and lower stables are old frame structures originally erected as temporary barracks during the civil war, about thirty-five years ago, when the island was occupied as a post for prisoners of war. They are all, especially the former, unfit for the purposes to which they are now put. It is almost a cruelty to a patient to send him for treatment to such a building, the like of which probably does not exist at any other military post. The inspector-general of that district, in his report of a recent inspection of the post, states: "The hospital is an old frame building, utterly unfit for hospital purposes and not worth repairing." Estimates have been repeatedly submitted, and they are again included this year.

MANUFACTURES.

During the fiscal year the infantry equipments, cavalry accouterments, horse equipments, material for target practice, artillery harness, field and siege carriages, caissons, battery wagons and forges, and many other articles required by the Army, colleges, and militia have been manufactured at this arsenal, and most of the issues to the Army, colleges, and militia have been made direct from this arsenal. The construction of the field and siege carriages, with their limbers, caissons, and battery wagons and forges, has also been pushed at this arsenal to the extent that the limited plant available for this work would permit, for the accumulation of the reserve of these carriages that will be required for immediate issue in case of emergency.

There is no special novelty about any of the fabrications except in the case of the saddletree and breech-mechanism covers for caliber .30 rifles.

EQUIPMENTS.

From 1865 until about a year ago our saddles have been made from saddletrees which were left on hand at the close of the war. This supply being exhausted and it being necessary to procure a new supply, the question was raised as to whether these trees should be manufactured at the arsenal or whether they should be procured by contract, as has been done heretofore. The trees procured by contract were not of as good quality as is desirable, but their serious defect was that being made by hand they did not conform in shape and dimensions to the rigidly exact requirements for a tree that will perfectly fit a horse's back. This subject received careful attention about twenty years ago and led to the construction of exact metal forms to be applied to the old trees to determine their variations from specified dimensions. The trees being on hand, to save the loss of throwing them away, greater variations from specified dimensions were allowed than would have been permitted in manufacturing new trees. Even with these greater variations it was found that as high as 45 per cent of the trees on hand furnished by some contractors during the war had to be rejected. Others conform more closely to requirements, but in all cases a large percentage had to be rejected.

It was my opinion at that time that these trees might be made with machinery, somewhat upon the same methods that are pursued in making gunstocks, lasts, etc. If so made it was thought that the form and dimensions of the trees might conform exactly to specified dimensions without any variations whatever, or rather that this exact conformity would necessarily result from the proposed method. It was also thought the devising of this machinery would better be undertaken in the arsenal shops, and if successful it would not only give the very desirable conformity to dimensions, but result in the construction of stronger and better trees in all respects. This work was undertaken and has been brought to a successful conclusion, and it is thought it not only results in better trees of accurate dimensions, but that the cost of the tree has also been somewhat reduced. A detailed report on the subject, made by Lieutenant Horney, is printed as one of the appendices to this report.

Some years ago reports from the Army showed that the operation of the breech mechanism of the new rifle might sometimes be interfered with by sand, snow, and frozen rain. Reports were called for from the Army as to the desirability of providing a protecting cover for the breech mechanism. Some of the reports stated that a cover was absolutely necessary, but the majority of the reports stated that none was needed. It was concluded that those officers who had had service in situations where a large amount of sand might blow into the mechan-

ism, or where it was exposed to snow and sleet or frozen rain, had found a cover to be necessary, and that others, who had not had such service, had arrived at a different conclusion. Various forms of breech cover were designed and tested, among others a metal cover which should constitute a part of the gun itself. Any cover of this kind was found to be highly objectionable in itself, and the attempt was abandoned. Moreover, it seemed better to provide a cover which need only be used on rare occasions when it was required. After many trials of leather covers, a light canvas cover, nearly waterproof, has been adopted, which can be wrapped quickly and securely around the mechanism and which can be removed in about four seconds if a sudden emergency requires immediate use of the arm. This cover weighs only 3 ounces. It is flexible, and can be folded in a small package and carried by the soldier in his pocket without trouble; it is inexpensive and its loss is not serious. Arrangements have been made for the issue of these covers to officers when going on any service that may render their use desirable.

FIELD AND SIEGE CARRIAGES.

Economy indicates the advantage of manufacturing all our field and siege carriages at this arsenal. Ample and most excellent shops were completed many years ago for this purpose and are available. Shop G was especially designed for this work. The limited plant which has been accumulated for this work was installed in Shop C and the general machine shop, which occupies two stories of one wing of this building. It is totally inadequate for producing carriages as fast as is necessary and has seriously crowded and interfered with the other manufactures carried on in this shop. The installation of this machinery in Shop G has therefore been commenced. It is very desirable that a sufficient plant should be installed for the production per annum of about 150 field carriages, 225 caissons, 25 battery wagons and forges, and about 36 siege carriages, with their limbers. This is the lowest rate of production that will provide the supply of carriages that would be absolutely necessary for immediate issue in case of emergency, and common prudence dictates that this plant at least should be provided. In installing the plant the work must be so done that the plant can be quickly extended in time of war to occupy the whole 3 acres of available shop floor in this shop. An estimate of $28,000 is included in the annual estimate this year for this plant. The work is of such extreme importance that prudence makes it almost imperative.

LIGHTING.

It is essential that arrangements should be made to run some portion of the shops at night, as more than once it has become necessary, where special effort was required to turn out certain stores promptly, to do night work, which, on account of inadequate lighting, caused considerable difficulty, as lamps and candles had to be used. A partial lighting

plant has been established, but it is not sufficient for general illumination of the offices and shops. More light should be provided, and an estimate for such a plant is submitted.

ROCK ISLAND BRIDGE.

The reconstruction of the superstructure of the combined railroad and wagon-road bridge over the Mississippi River from the arsenal to Davenport (known in acts of Congress and reports as the "Rock Island Bridge") was brought to a successful conclusion in the fall of 1896.

The original bridge was completed in 1871. At the time of its construction it was deemed to possess sufficient strength to meet the utmost future requirements for traffic. The railway traffic has, however, been multiplied many times beyond expectations. The weights of engines and cars and their loads have been multiplied in recent years. The wagon way has been thrown open to the use of the public and has become thronged with traffic, which was not intended when the bridge was constructed, and its use by electric street railways has been permitted, all of which has overloaded the bridge and subjected the structure to strains for which it was not intended. The old bridge, under these circumstances, has lasted twenty-five years. The deterioration due to this overloading and long service caused the commanding officer (Col. A. R. Buffington), in 1894, to report the necessity for reconstructing the bridge. In 1869, when the bridge was originally planned by the Ordnance Department, it was intended that it should provide for a double-track railway. Through some changes which crept into legislation the bridge was constructed to provide for only a single-track railway. The increase of traffic made a double-track railway absolutely necessary, and the use of the wagon way by the public and by street railways also made a wider wagon way very important.

As the strains due to overloading the bridge rendered its reconstruction necessary, it was determined that the new bridge should have sufficient width for the double railway track and the increased width of the wagon way, and it has been so constructed.

The act of Congress authorizing the reconstruction of the bridge was approved March 2, 1895. The conditions of its erection required the contractors to keep the railroad track intact across the river for the passage of trains, and the erection of the draw span was provided for, so as to insure that there should be no obstruction to river navigation. These conditions were met to such an extent that navigation was interrupted for a few hours only. Each span of this structure is practically an independent bridge, and of such a character, with respect to material and design, as to meet the needs, not only for the present, but it is believed for a long time in the future.

Bidders were permitted to submit their own designs, and bids were based on them, as well as on the Government design, in order that everyone desiring to do so should have an opportunity to bid. Thus the

work was thrown open to the greatest possible competition, and the Government was given full latitude in making its award consistent with the exceptional material and workmanship demanded.

The cost of the bridge has been $490,000, the amount appropriated for it, of which but 3 per cent has been expended for inspection and expert services. For a structure of this magnitude these expenditures will compare favorably with the cost of any bridge of like character now existing. The work of reconstruction was under the charge of Col. A. R. Buffington, Ordnance Department, the commanding officer of the arsenal at the time.

It is regretted that in the erection of the bridge two lives were lost, but the responsibility in each case appeared very clearly to rest with the men injured, and could not be charged to negligence on the part of the contractors.

Pending the construction of this arsenal, from 1870 to 1886, the annual reports describing the operations of its construction were generally published in the annual reports of the Chief of Ordnance. One of the features of these reports, most valuable for future reference, was the descriptions of the foundations of the buildings. The report of the operations for the year 1878 for some reason, was not published, and in this report was the description of the foundations for Shop G. As this description is important, an extract from the annual report of 1878 containing the description and drawings of the foundations of this shop is published as an appendix to this report.

WATERVLIET ARSENAL.

SEACOAST-GUN FACTORY.

During the past year work on gun construction has progressed satisfactorily and as steadily as the supply of forgings and the state of the appropriations for finishing and assembling guns would permit. In the early part of the year the force of machinists in the large gun shop was increased to nearly its full capacity for day work and a night force of about forty machinists was added. The use of two shifts has been continued throughout the year, and has resulted in an increased output and a considerable saving of cost of production.

In the manufacture of seacoast guns of model 1888 considerable difficulty has been experienced in securing suitable bronze castings for breech plates and consoles, which has delayed more or less the manufacture of the guns. In guns of new design, model 1895, no breech plates are required, and the difficulty with the consoles is avoided by the use of cast steel instead of bronze.

The reductions made by Congress on the Department's estimates for forgings for seacoast guns for the three years previous to 1896 have been seriously felt this year in the limited supply and slow rate of delivery of the forgings, and has materially affected the yearly output of finished guns. So noticeable was this that toward the close of the

year the entire hoop, tube, and jacket departments had not a single forging in hand. In spite, however, of the difficulties and delays mentioned, the output for the past year, as given below, is greater than that of any previous year. The number of guns completed in the seacoast gun department during the year is as follows: Thirteen 8-inch, twenty-two 10-inch, and seventeen 12-inch guns. To obtain the output for the year, the amount of work on guns in hand and unfinished at the beginning and end of the fiscal year should be taken into consideration. In doing this the output for the year is as follows: 6.65 8-inch guns, 21.2 10-inch guns, 19.9 12-inch guns, and 7.35 12-inch mortars, or a total output of 55.1 heavy cannon, being about 50 per cent more than the output for any preceding fiscal year. The tonnage output for the year was 1,876 tons of heavy cannon, an increase of 61 per cent over the largest output of preceding years. The saving in cost of finishing and assembling during the past year has been about 20 per cent over the cost of preceding years.

FIELD AND SIEGE GUN FACTORY.

In the small gun shop the six 7-inch B. L. siege mortars unfinished at the close of the last fiscal year have been completed. For several months afterwards this shop was without work, but in December last orders were placed for the manufacture of thirty 3.2-inch B. L. rifles, ten 5-inch B. L. siege rifles, ten 7-inch B. L. siege howitzers, and twenty 7-inch B. L. siege mortars. The first forgings, however, for these guns were not delivered until the middle of March. Work on all these cannon is now in progress. Two 5-inch R. F. guns have been under manufacture during the year; one, a built-up gun with the Driggs-Schroeder breech mechanism, is completed; the other, a single-forging gun with Gerdom breech mechanism, is nearly completed.

Considerable other work has been done in this shop, such as repairs of siege guns, small parts for the breech mechanism of seacoast guns and other guns, and the preparation of gauges, templets, inspecting instruments, etc., for the use of inspectors at other establishments. The shops are now provided with a complete outfit of jigs, standard templets, and gauges, to insure accuracy of finish and interchangeability in various parts of service guns.

LOWER SHOPS.

The carpenter, blacksmith, and machine shops east of the canal have been run uninterruptedly during the year by the water power, with the exception of a few weeks occupied in the repairs of the canal by the State, during which period these shops were satisfactorily operated by electrical connection with the gun shops and the temporary conversion of an electric-light dynamo into a motor. These shops have been utilized, as heretofore, in connection with the electric plant, for the repair and construction work of the arsenal and gun plant, in painting and boxing projectiles, the manufacture of armament chests for siege and

seacoast guns, tools and implements for the same, and penthouses for 8 and 10 inch B. L. rifles mounted on depressing carriages; also the preparation and issue of shells for field and siege guns and the manufacture of gas-check pads of various calibers, together with numerous articles for filling current orders for supplies. A material reduction has been made in the cost of some of these items, especially in the armament chests, and it is expected that a further saving in the cost of tools and implements can be effected during the coming year.

BUILDINGS, PLANT, AND OTHER CONSTRUCTION WORK—GUN FACTORY.

The equipment of the south wing for finishing and assembling 16-inch B. L. rifles has been completed. All four of the 16-inch gun lathes which were in process of erection last year were, upon completion, carefully inspected, and some work on 12-inch guns and jackets has been performed on them to test their efficiency. The machines have all worked satisfactorily. All shafting, belting, and friction clutches for these lathes have been completed and successfully operated.

Some changes have been made in the hoop and jacket furnaces to accommodate them to the increased lengths of those parts in guns of model 1895. The increased length of the jacket in guns of this model has also necessitated a lengthening of the jacket lathes in the south wing. A trolley rail with differential hoist has been placed over these lengthened lathes in order to facilitate hoisting the heavy cutter threads and taking them in and out of the boring bars. An experimental oil furnace for shrinkage operations has been constructed with the view of obtaining some data and experience in this line before proceeding with the construction of one large enough for 16-inch guns. The results so far have been satisfactory.

WATER-POWER PLANT, ELECTRIC LIGHT AND POWER PLANT.

The water-power plant, as previously described in last year's report, has been in successful operation during the year. It has been necessary, however, on several occasions to run the lower shop by means of electricity from the gun shop, and it has been both safe and economical to do so when the water-power plant is out of action. In order to increase the motor capacity, arrangements have been made whereby both generators at the lower station can be operated as motors simultaneously, thus giving a capacity sufficient to run the pumps and all the machinery in the lower shops at the same time.

The electric light and power plants have been operated during the year with satisfactory results, very little repair having been necessary. The electric motor for the main hoist of the 60-ton crane has, on several occasions, been overheated, destroying the insulation and causing short circuits. This is due to the great strain on this motor, in which the whole weight being suddenly applied there is no opportunity for a gradual increase of the speed and power of the motor.

WATER SUPPLY.

The new water tower with its equipments has been in successful operation during the year. A new tank and supplementary 5-inch distributing main have been installed. The connection of the 5-inch force pump with the 6-inch distributing main lying north and east of the lower shops has been made, and the following advantages obtained: The post can now be supplied by means of the 6-inch and 8-inch distributing mains in case of accident or repairs to the 5-inch force main; also in case of fire the pumps can force water through the 5-inch force main and 6 and 8 inch distributing pipes at the same time. In order to more fully protect the gun factory buildings against fire, a new 6-inch pipe was laid and a number of hydrants placed around the entire south end of the large gun shop. This new pipe is connected with the 8-inch distributing main.

For the inside protection of the gun shop a complete circuit of 4-inch water pipes has been laid, to which are connected twenty-six 3-inch valves, supplied with 50 feet of fire hose, with nozzles attached.

The above arrangements are shown on plates accompanying the reports of the commanding officer, Watervliet Arsenal, which form an appendix to this report.

WATERTOWN ARSENAL.

SEACOAST-GUN CARRIAGE FACTORY.

The shops at this post have been employed to their full capacity during the year, and for several months the more important tools were kept running sixteen hours a day. Aside from the purchase of some small drills, bench lathes, improved grindstones, vises, etc., the principal addition to the manufacturing plant has been an iron planer 12 feet 2 inches by 10 feet by 25 feet. This tool has the requisite capacity for the manufacture of 12-inch disappearing carriages, and as regards all other heavy work, its capacity, stiffness, and accuracy permit of doing the work both quickly and well.

Among the machine tools on hand, some few planers, lathes, boring mills, shapers, and slotters, which were part of the original equipment of the shops before the installation of the present carriage plant, have now become worn out and need to be replaced by new and more improved tools. For this purpose there is an available appropriation of $15,000, which is about one-half the sum that will be required. The following carriages, which were under construction at the beginning of the year, have since been completed, viz: One 10-inch disappearing carriage, model 1894; six 12-inch mortar carriages; two 15-inch altered smoothbore gun carriages; six 7-inch siege-mortar carriages. The following carriages were commenced and have been completed during the year, viz: One 12-inch disappearing carriage, model 1896; four 12-inch barbette carriages, model 1892; five 10-inch disappearing carriages, model 1894; two 8-inch disappearing carriages, model 1894; twenty

7-inch siege-mortar carriages and platforms; twenty 3.6-inch field mortars and platforms, and in addition the following have been commenced and partially completed: Four 12-inch disappearing carriages, model 1896; three 8-inch disappearing carriages, model 1894, and three 12-inch gun lifts to be altered to 12-inch barbette carriages.

Besides the above work, a certain number of models of siege and seacoast carriages, one-tenth size, have been made for issue to the United States Military Academy.

The manufacture of carriages occupies probably two-thirds of the facilities and time of the shops, the other third being occupied in the manufacture of cast-iron shot and shell of various calibers, machines for garrison service, mechanical maneuvers, for mounting and dismounting guns and carriages, implements for the service of seacoast guns, inspecting templets, gauges, calipers, etc.

FOUNDRY.

This shop has been crowded with work to its utmost capacity throughout the year. Should an extension of capacity become necessary, this can be accomplished by removing some machines from the compartment at the west end of the building and extending the foundry to that end. It is deemed important that the Department make its own castings, not only for economical reasons, but to maintain a high standard of quality. Castings of very high quality have been produced here, which are sound, free from sand or blowholes, easy to work, tough, and strong. The tenacity runs uniformly in the neighborhood of 33,000 pounds per square inch. A crane of increased capacity is also required in connection with the enlargement of the foundry.

Good results have been obtained from the brass foundry. In addition to carriage castings, breech plates and consoles for seacoast guns have been produced. Some difficulty has been experienced in getting good, sound castings for consoles, but the breech plates and other castings have shown a tensile strength of 50,000 pounds per square inch, with an elongation of from 30 to 40 per cent.

FORGING DEPARTMENT.

A portion of the forgings required in carriage manufacture are forged in the smith shop from billets purchased from private manufacturers. The largest piece forged was a gun lever axle for a 12-inch disappearing carriage, the rough-forged weight of which was about 8,400 pounds. The facilities are not quite equal to the requirements for handling such large pieces with speed and economy, and it is deemed advisable to increase somewhat the facilities of the smith shop by putting in a 15-ton crane and larger steam engine. During the year this shop has been reconstructed to a great extent. The furnace was rebuilt and made as large as practicable, and a larger boiler was put in place. A bolt-heading machine, capable of making bolts up to 2 inches diameter, has been put in, and effects an important saving in the cost of bolts.

By improved arrangements in the reconstruction of this shop, and

by the erection of a 15-horsepower engine to run the shears, a saving of about 40 horsepower has been effected in the service of this shop, while the appearance of the shop and convenience of operations have been greatly improved.

POWER PLANT.

The boiler plant has been reconstructed and renewed entire during the year. The four boilers of 50-horsepower capacity have been replaced by three boilers of about 125 horsepower, each at 75 pounds pressure. These are set on a line perpendicular to the old line of boilers to admit of the entrance of a narrow-gauge track for bringing in coal. The machine-shop engine of 150 horsepower is overloaded, and the power requires to be nearly doubled. This will be done with money now available for the purchase of another engine. The delay is due to efforts to secure the utmost economy of space for the increased engine plant. In addition to the machine-shop engines, the boilers also supply steam to the carpenter-shop engine of about 75 horsepower, and to the testing-department engine of 15 horsepower, and heat for all the shops.

ELECTRIC PLANT.

An electric lighting plant was installed during the year. It has been now in operation for several months and has given entire satisfaction.

TESTING DEPARTMENT.

During the year the testing department has carried on, as heretofore, public tests in the examination of material for acceptance, representing the current work of this and other arsenals and places where Government work is in progress. Investigation tests have been continued, also tests made for private parties who have availed themselves of the use of the testing machine and defrayed the cost of such tests provided by law. The public tests of material for acceptance include material for field and siege guns, howitzers, and seacoast guns and mortars, the test of steel for small-arms barrels and receivers and for machine guns, the material used in 8, 10, and 12 inch carriages, and anchor bolts for the same. Tests have also been made of helical springs for mortar carriages, balata slabs for buffers, cast and pig iron from the arsenal foundry, steel plates for arsenal boilers, chain iron, cast copper cylinders for pressure gauge, bronze breech plates and loading trays from Watertown Arsenal foundry, all of which material pertained to the Ordnance Department. Tests of steel bars were made for the Engineer Corps, United States Army, chain cable for the Light-House Board, a large swivel shackle for the Bureau of Equipment, Navy Department, and shot lines for the Life-Saving Service.

Among the investigation tests are additional experiments on the hydrostatic test of the 8-inch tube section, supplementary to the main series of tests, which have been completed. The scope of the investigation of this tube section has been so extended as to include all cases

of simple strains and nearly all cases of simultaneous orthogonal strains to which the tube of a gun would be ordinarily exposed. The exact results, confirmatory as they have been to accepted formulæ, are believed to have a value fully justifying the large labor involved in carrying out this unusual series of determinations. Heretofore in these tests the strains have been maintained within the elastic limit of the metal. Preparations are now being made to follow with overstraining forces and investigate the effects thereof. Other tests have had for their object the determination of the elastic properties and tensile strength of steel music wire of high grade. Additional samples of "vibration proof" bolts and nuts were submitted by the manufacturers for test as to their ability to withstand unlocking while subjected to vibratory influences. The tests made confirmed earlier experience and failed to substantiate their claim to being "vibration proof" under the condition of jarring with hammer blows.

A number of samples of granite from the State of Georgia, contributed by the Geological Survey, were received and tested. Brick and terra-cotta samples, also, from the Pacific Coast and from the State of Ohio were tested. Other tests of building materials comprise the test of an important series of cement concrete cubes and columns. The columns were of different heights, and made up of different proportions of cement, sand, and gravel. The ultimate crushing strength of the material was ascertained and full observations made on the compressibility and resilience under successive increments of loads. In this class of material, by varying the proportions of the constituents, it is possible to exert a controlling influence on both the ultimate strength and rigidity as shown by the modulus of elasticity of the columns. The prominence which concrete construction is assuming makes the data developed by these tests of much practical value in architectural designs.

The strength of cordage was ascertained in another exhaustive series of tests. The experiments included manila, hemp, sisal, and cotton rope, in the various commercial sizes, from a 6-thread manila line to a 10-inch rope.

An interesting series of tests have been made on full-sized wooden posts—new posts of long and short leaf pine and spruce and old long leaf pine posts from a building where the latter had been in use for a period of about fifteen years. The tests represented different degrees of dryness of the wood, the percentage of moisture being ascertained by test. The strength of the old posts, which were extremely dry, largely exceeded the strength of the comparatively green sticks.

The occasion of installing a battery of new boilers into the arsenal plant gave an opportunity to make some interesting observations on the behavior of riveted joints in actual construction, supplementary to the test of joints in the testing machine. These tests are all described with more or less detail in the report of the commanding officer of

Watertown Arsenal, which forms an appendix to this report, and will be given more completely in the forthcoming annual report on the tests of metals, etc., at Watertown Arsenal. In conection with the testing department at this post an impact machine has been designed. It is of the vertical type and will admit of attaining velocities of about 20 feet per second. The parts of the apparatus are very massive for furnishing the rigidity required under the shock of testing.

It is proposed to introduce microscopic metallography in the investigation of constructive materials, and the appliances necessary to this end have been obtained.

It is unfortunate that the publication of the annual report of these tests (its title is "Tests of Metals," etc.) has heretofore been so long delayed after the preparation of the report that the public has thereby sometimes been deprived of information of a high value for from one to two years. Also, a late law has so restricted the number of these reports that may be printed that not one-third of those called for can be supplied. On this account the above somewhat lengthy summary of some of the more important tests is inserted here.

WHARF ON CHARLES RIVER.

The wharf upon the Charles River, for which there was an appropriation, has been completed in a substantial manner. A railroad connecting the wharf with the shops and the Fitchburg Railroad is being built, which will soon permit the shipment of carriages by both rail and water. The latter method is often most economical and convenient, when vessels must be employed at the latter end of the route to reach fortifications. The larger carriages can be shipped in no other way, as some of the parts will not pass through railroad bridges and tunnels.

OFFICE.

A suitable office for this arsenal has become an absolute necessity. The present office was constructed in 1816, for an establishment of about one-tenth the capacity of the present arsenal. The office duties, including the drafting department, are probably twenty times as much as the duties performed when this office was built. The building is insufficient in capacity, is not fire proof, and is totally unfitted for present requirements. An urgent request for a suitable office is included in my annual estimates for this arsenal for the present year.

NORTH BEACON STREET.

The matter of the condition and control of North Beacon street is calling for some definite settlement. April 25, 1824, the President of the United States gave a revocable grant to the Waterford Turnpike Corporation for the passage of a turnpike road through the lands of the United States at this arsenal. This road is now a part of North Beacon street, one of the main avenues of travel between Boston and

Watertown and the towns beyond. The turnpike corporation long ago passed out of existence and the road reverted to the United States. It is, however, used by the public and is nominally under control of the town of Watertown. But it is in bad order for travel, very little repair is ever made to it, and no police supervision is exercised over it. It is unsafe for travel at night by reason of want of police control. An act of Congress should grant the road to the town of Watertown.

SPRINGFIELD ARMORY.

The manufacture of new arms during the year ended June 30, 1897, comprised 28,899 magazine rifles and 2,930 magazine carbines, model 1896. The rifles of model 1892 on hand have been fitted with sights of model 1896, and altered to introduce as far as practicable the improvements pertaining to the later model. During about two and one-half months of the year the quality of steel for barrels required was not furnished by the contractor. This caused a suspension of the manufacture of barrels and the assembling of completed arms, though the manufacture of the other parts of the arm was continued. The delivery of suitable steel for barrels commenced in May. The rate of production of barrels was then increased, and the number of arms assembled was increased to 200 per day. This will continue until the accumulated parts are exhausted, when the production will be reduced to the regular rate of 120 arms per day. This has reduced the output of arms slightly for the year, and will increase slightly the output during the present year.

A high state of efficiency has been reached in the methods and appliances for manufacture, and arms of superior quality and workmanship are being produced. The continued minor changes in operations made during the year to improve methods and reduce the cost of manufacture are outlined in the appended report of the commanding officer of the armory. By the introduction of "face milling" machines one machine has taken the place of nine plain milling machines, and the amount of work per day increased several fold. The use of gasoline gas in the water shops has been largely abridged, the forges have been altered to burn coal, and city gas introduced for illuminating purposes. An electric-light plant is required for lighting these shops and an estimate for it has been made, as well as for needed additions to provide closets in connection with these shops and the milling shops.

In the main arsenal an hydraulic lift has been erected, capable of carrying a load of 1,200 pounds to the third floor. This has added greatly to the value of the building as a storehouse.

The city has recently graded and macadamized the portion of Allen street, the property of the United States, lying along the land about the water shops, and the tracks of the Springfield Street Railway are now to be extended over Allen and Mill streets, under a "revocable license" granted for that purpose by the Secretary of War.

FRANKFORD ARSENAL.

The plant for small-arms ammunition has been increased by the addition of some machines and has a present capacity for about 34,000 ball cartridges, caliber .30, and 16,000 miscellaneous cartridges; total, 50,000 per day. During the past year there were manufactured about 15,400,000 ball and blank cartridges of calibers .30, .38 (revolver), and .45. Of the 6,771,620 ball cartridges, caliber .30, manufactured, 5,872,240 were required to be issued to the service, leaving only a small reserve. During the present year a greater number of these cartridges will be made, but at the expense of the capacity of the plant to produce other ammunition. Any material increase of this capacity is prohibited by the inadequacy and crowded condition of the buildings now occupied, and it is hoped that the estimates will be granted which have been submitted for removing this plant to another building, now vacant, at the arsenal.

Minor improvements have been made to increase security from danger of explosions attending the operations of manufacture and from fire. With the cartridge-loading machine in use at this arsenal it is known that a charge of 4 or 5 pounds of black powder would not, if exploded, injure the operatives or affect the building. This has been previously proved experimentally and by an accidental explosion when three operatives were at the machine. An experiment has been recently made with the smokeless powder now in use, purposely placed in the loading machine under the most adverse conditions. The charge of 4 pounds burned with an intense flame about 6 feet high, but no explosive effect.

The production of artillery ammunition has included shrapnel for 3.2-inch, 3.6-inch, 5-inch, and 7-inch cannon; canister for 3.2-inch gun, and fuses, with a number of sights for cannon, including the brackets for fitting telescopic sights to seacoast guns, gunners' quadrants, cannon primers, and inspecting instruments. A design of shrapnel, 55 pounds, for the 5-inch rapid-fire gun has been prepared and samples made which are now awaiting test in the gun at the Sandy Hook Proving Ground. The manufacture of drawn cases for 3.2-inch field gun has been suspended for the present. Several new designs for 3.2-inch shrapnel have been prepared with a view to improvement upon the present projectiles, and samples of these of four different patterns are now being made for trial.

The experimental work of the arsenal has included investigations of the cause of brittleness in fired cartridge shells, looking to the production of a good reloading cartridge for smokeless powder; the determination of data for the trajectories of the .30-caliber rifle and carbine and of the effect of temperature on the cartridges in producing changes of velocity, and tests of varieties of smokeless powder and their erosive effect in the rifle. The chemical laboratory has been continuously

employed in the examination and tests of material, including powders, explosives, oils, and cartridge metal. Several reports of the officers concerned in these investigations are herewith appended.

SANDY HOOK PROVING GROUND.

Firings for experimental and proof purposes have been conducted daily during the year whenever the weather and other circumstances would permit. The nature of these firings and their results are summarized in the pages appended to the report of the commanding officer of Sandy Hook Proving Ground.

In connection with the installation of the new machine tools mentioned in my last report, a wing has been added to the machine shop, a central portion of the floor of which is provided with a broad-gauge track connected with the regular railroad system of the post. Cars containing guns, the heavy parts of carriages, etc., requiring repairs, can now be run directly into the shop for that purpose. The efficiency of the shop is thus greatly increased, and the changes and repairs constantly required in connection with the experimental firings and tests can now be effected with greater promptness and economy than heretofore.

The following guns, mortars, and carriages of new construction have been issued from this post during the year for installation in seacoast fortifications built especially for their reception:

Two 8-inch B. L. rifles, steel;
Twenty-eight 10-inch B. L. rifles, steel;
Six 12-inch B. L. rifles, steel;
Six 12-inch B. L. mortars, steel;
Six 10-inch disappearing carriages;
One 12-inch barbette carriage;
One 12-inch gun-lift carriage;
Six 12-inch B. L. mortar carriages.

During the month of November a heavy easterly gale carried away about 3,500 feet of the narrow neck of sand which joins the reservation to the mainland of the State of New Jersey, and over which neck the railroad ran connecting the proving ground with the Central Railroad of New Jersey. Fortunately, the piles of the trestlework built over this neck were driven about 5 feet into clay. This trestlework was, therefore, in no way injured by the storm. It has been found necessary, however, to extend the trestlework for 1,350 feet, in order to maintain the necessary connections. This work was done at the expense and under the direction of the Quartermaster's Department. A great reduction in cost of transportation, not only directly, but on account of the competition with water transportation, has resulted from the existence of this trestle, fully justifying the expense incurred in its erection.

An electric plant for exterior illumination, the lighting of officers' quarters, and for use in connection with the experimental firings and tests, has been installed at the proving ground during the past year.

For the plant there were already on hand a high-speed engine and dynamo as a part of an electric hoisting plant. To complete the plant called for, the purchase of a storage battery placed in position, wiring of the office and officers' quarters, and the purchase of fixtures only was necessary.

The battery room is located in the cellar of the office building, which, by putting in a concrete floor and larger windows, furnished an excellent location. Besides lighting, the battery is used in the office for the call bells, the annunciator, the anemometer, and the Boulengé chronographs, as well as for firing and testing purposes. It permits of dispensing entirely with the primary batteries, which had been used exclusively for these purposes. The storage-battery cells, on account of their internal resistance being negligible, and having a constant voltage for small currents, furnish the very best type of cell for the chronographs, or in fact for any work in which an absolutely constant current is essential. Each Boulengé chronograph is provided with a group of four cells in the battery, and the resistance of the wires is made so small that it enables the current for both registrar and chronometer to pass through a make-and-break switch near the instrument. This switch breaks the currents in both the registrar and chronometer simultaneously, eliminating any error in the time of disjunction, except that due directly to the magnets themselves, and replaces the disjunctor, which has always been a source of error. The battery wiring is done entirely with No. 6 copper wire, okonite insulation. The maintenance of the battery is trifling in cost compared with that of the primaries. About twice a week the cells are refilled with water to replace loss by evaporation, and to maintain the specific gravity of 1.2. The cells rarely demand acid.

SMALL ARMS AND SMALL-ARM AMMUNITION.

All of the .30-caliber magazine rifles and carbines manufactured during the year are of model 1896.[a] The distinguishing features of this as compared with the model 1892 were described in General Orders, No. 14, Adjutant-General's Office, March 31, 1896, except, as since introduced in manufacture, the strengthening of the safety lock by adding metal to the thumb piece to obviate accidental breakage, and a receptacle made in the butt of the stock for carrying a small oiler of brass, nickeled, in each arm, with the sectional cleaning rod.

A useful manual entitled "Instructions for United States magazine arms, caliber .30, in the hands of troops," is contained in the appended report of principal operations by the commanding officer of the Springfield Armory. These instructions have been supplied to the troops.

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[a] In my last annual report the following sentence appears near bottom of page 17, with reference to the rear sight, model 1896, viz: "This position is found to give a close correction for drift at all ranges up to 1,000 yards."

This is incorrect, and the sentence should read: In this position the deviation due to drift will be, at most, slight at all ranges up to 1,000 yards.

Their principal object is to enable the repairs of arms and replacement of parts which must be performed by the troops to be done intelligently, and they contain in a condensed form a statement of the parts which are most liable to require repair, with instructions for replacing broken parts, for precautions to be observed therein, and also for the use of a partially disabled arm. The last is particularly important since it is one of the valuable features of this arm that the independence of the magazine mechanism is such that this mechanism may be totally disabled without interfering with efficient use of the arm as a single loader.

Steel for .30-caliber gun barrels.—The steel now used for barrels at the Springfield Armory is a simple carbon steel made by the Bessemer process from carefully selected material and required to give a determined analysis. The physical qualities required are: Elastic limit, 70,000 to 75,000 pounds; tenacity, 100,000 to 120,000 pounds; elongation, 15 to 20 per cent, and contraction, 35 to 45 per cent. It is received in bars 1.15 inches in diameter, from which the barrels are made. This standard has been reached with considerable difficulty and the examination and test of numerous samples of steel furnished by different makers. Various methods of treatment have also been investigated to put the barrels in good condition for machining, and to restore the properties of the metal after the rolling operation. It has been deemed necessary to subject the barrels to a pressure of about 75,000 pounds in proof, in order that only reliable barrels may be allowed to pass. A number of barrels have been made from nickel steel, resulting in a large percentage of rejections in the progress of finishing them. More difficulty was experienced in machining these barrels than with simple carbon steels, and the great difficulty that appears to exist in producing this metal uniform in structure and free from seams gives little encouragement for its further trial at present.

Investigations are being made to determine the practicability of applying the Rodman process to increase the resistance of the barrel by interior cooling.

In the course of experiments at the Springfield Armory to determine the extent of erosion in barrels of different steels, a number made of nickel, open hearth, and Bessemer steels have been tested by firing 5,000 rounds from each barrel, in groups of 500 rounds fired in thirty minutes. Some other barrels remain to be tested in this series of experiments and no complete report of the results has yet been received.

Tables of fire, .30 caliber rifle and carbine.—Extensive firings have been made during the year to determine the elements of trajectories for these arms, including drift and the effect of wind, and data for computations. The results have not yet been wholly compiled, but will be published in the appendices to this report. The attainment of sufficiently accurate results in these experiments involves many difficulties, especially the firings for determining the effect of winds of varying

velocities. Some 15,000 rounds have already been fired, most of them at the Springfield Armory firing ground. For some of the longer ranges the firings were made at the Sandy Hook Proving Ground. By measurement of the remaining velocity at 500 yards range a value for the coefficient of reduction, C=0.9, for the bullet was obtained as applicable to both arms. The difference in muzzle velocity of the rifle and carbine firing the same ammunition is found to be about 80 feet per second. The tables of fire for the two arms, appended hereto, have been computed and further verified by comparison with trajectories of the arms determined by firings. The maximum range computed for the rifle is 4,066 yards, angle of elevation 44°, time of flight 34.6 seconds, and for the carbine 4,016 yards, angle of elevation 44°, and time of flight 34.3 seconds. In firing lying down against infantry, and aiming at the foot of the object, supposing the ground to be level, a distance of 565 yards may be taken with the rifle in which the bullet in its flight will not pass above the height of a man (68 inches), and similarly the danger range of the rifle against cavalry is 638 yards, taking 96 inches as the height above the ground of a man on horseback.

Recent experiments at the Springfield Armory have shown the following penetrations in firing with the .30-caliber magazine rifle with service ammunition and targets placed at 53 feet:

Iron boiler plate, 0.4 inch thick, backed. Penetrated.

Iron boiler plate, 0.468 inch thick. Penetrated.

Same plate, backed. Penetrated 0.46 inch and bulged plate at back.

Iron boiler plate, 0.566 inch thick, backed. Penetrated 0.255 inch.

Soft steel plate, 0.2 inch thick, backed. Penetrated.

Seasoned oak across grain, exceptionally hard and tough. Penetrated 20.7 inches.

White-pine target of 1-inch boards, spaced 1 inch apart. Penetrated 45.8 inches of pine.

At 500 yards range, in the same target, the penetration for the .30-caliber rifle was 19.85 inches of pine; for the .30-caliber carbine, 17.96 inches; and for the .45-caliber Springfield rifle (lead bullet, 500 grains), 12.85 inches.

At 1,000 yards range, in the same target, the penetrations in pine were: .30-caliber rifle, 11.44 inches; .30-caliber carbine, 11.22 inches, and .45-caliber Springfield, 8.44 inches.

An interesting report is appended of experiments made at the Frankford Arsenal to determine the deviation of .30 and .45 caliber rifle bullets from wind pressure produced by artificial means. When the two bullets suspended as pendulums were exposed to the same blast of wind for a period of time the .30-caliber bullet was deflected more than the .45 caliber. But when the shorter time of flight for the .30 caliber for a given range is considered it appears that this bullet should be less deflected by the wind than the .45-caliber bullet in actual firings. The deductions from the experiments are that the deviation of the .30-caliber bullet due to wind should be about two-thirds that of the .45 caliber at 200 yards range, with increasing proportion up to about nine-tenths that of the .45 caliber at 2,000 yards range. These results can not be taken as a true representation of the effect of wind upon the

same projectiles in actual flight, for the circumstances are different, but are instructive and useful for comparison, since a correct determination of the wind effect by direct experiments in actual firing is, as is well known, very difficult of accomplishment.

REVOLVERS.

The troops in service are now fully armed with the double and single acting Colt's revolver, caliber .38, model of 1894, except the batteries of light artillery, which are armed with the former service pattern of .45-caliber revolver, having the barrel shortened to 5.5 inches. The exchange of .38-caliber revolvers, model 1892, in service for those of model 1894 has been accomplished, and the revolvers of model 1892 turned in will be altered to model 1894 for reissue as required.

The reports from service use of the .38-caliber double and single acting revolver are generally favorable, but the rather complicated mechanism of the arm requires it to be handled with more care than the .45-caliber single-acting revolver, recently in service. An unusual number of repairs are called for from the service. The caliber of the arm and weight of bullet are also thought to be too much reduced for efficient cavalry service, and with the view to the adoption of a new revolver when the present supply requires replacement the question is now being considered of designing a revolver which will be less complicated than the present .38-caliber pattern, to be of larger caliber and use a heavier bullet with relatively low velocity.

The new features in the .38-caliber revolver which add to complication of the mechanism are (1) the appliances for revolving the cylinder to one side for loading and for simultaneous ejection of the empty shells; (2) the double-action or self-cocking attachment. Request was made in November, 1896, for opinions in regard to the advantage or efficiency in combat of these two principal features of the revolver from all troop commanders in the service. These reports have been received and will be given due consideration in connection with question of caliber and ballistic requirements of the revolver.

SMALL-ARM AMMUNITION.

The .30-caliber ball ammunition with strengthened case, the manufacture of which was begun in September, 1895, and the blank cartridge with paper bullet have given satisfactory results in service, and no further changes in ammunition have been introduced. The supply of the pattern of ball cartridge made prior to September 1, 1895, has been exhausted and their use discontinued in service. The former model of .30-caliber blank cartridge with black-powder charge has also been entirely displaced in service by the paper-bullet blank charged with smokeless powder.

The expectation that the fired .30-caliber cartridge shells turned in from the service could be used for reloading has not been realized.

The metal of the case in a comparatively short time after being fired with smokeless powder generally becomes brittle and unfit for further use. Investigations are now being made to produce a reloading cartridge. The principal cause of brittleness in the present shell, which is made of brass (70 copper and 30 zinc), has been traced to the action of the mercury in the primer composition on the metal of the case, particularly on the zinc. The loaded cartridges when new can be safely kept. No deterioration occurs until after firing, when the primer is burned and the gases liberated within the case. At the present stage of the investigation it is expected that a serviceable reloading cartridge will be produced by reducing the amount of mercuric fulminate in the primer, in conjunction, possibly, with the use also of an alloy of copper for the metal case containing a reduced percentage of zinc.

Another form of reloading case was proposed by Lieutenant Dunn in April, 1897. The feature of the design is a sliding base sealed with a rubber ring. It is in some respects similar to the Morse cartridge, but differs from it in essential particulars. It offers the advantage of using an alloy for the case containing a relatively small percentage of zinc, such as gilding metal, so called (93 copper, 7 zinc), which is little susceptible to the brittleness stated, but which when made into the present form of solid head case does not afford sufficient strength of cartridge with the high pressures attained in the .30-caliber rifle. A quantity of cartridges have been made and tried on this design with favorable results for reloading endurance. Their durability under continued storage tests is now being tried.

Investigations have been made upon the utility of tinning the case of .30-caliber cartridges charged with smokeless powder. The conclusions reached are that under normal conditions of storage, brass cartridge cases do not need protection against erosive action of either black or smokeless powder. When moisture is present in excess or when the powder has suffered material decomposition, a slight protection, acting at least to defer such action, is afforded by the tin coating, and this, taken in connection with the neat and distinctive appearance given to the finished product, is sufficient to justify the use of tinning. This practice was introduced in the manufacture of small-arm cartridges at Frankford Arsenal in 1888, when brass was substituted for copper as the material for the case of reloading ammunition.

Effect of temperature on velocity.—It has been observed that there is a marked tendency to rise and fall of velocity of smokeless-powder ammunition, depending upon the temperature of the cartridge when fired in the arm. Recent experiments have been made with .30-caliber rifle cartridges to determine the changes in velocity for a scale of temperatures ranging from -40 to $+130°$ F. at intervals of 10 degrees. Each lot of cartridges was brought to proper temperature by exposure for twenty-four hours in a chamber having the desired temperature. From these experiments and the data derived from repeated "heat" and

"cold" tests previously made in the laboratory at Frankford Arsenal, the following average results for service ammunition have been deduced: The velocity of the .30-caliber rifle varies about 120 feet per second between the limits of temperature given. Taking the standard of 2,000 feet per second for a temperature of 70° at proof, it diminishes for each 10° fall of temperature by decrements varying from 8 to 3 feet per second, and at −40° loses about 43 feet per second; and for each 10° rise of temperature it increases from the standard by increments of from 10 to 12 feet per second, and at 130° gains about 65 feet per second.

.45 caliber ammunition.—The recent law extending the use of the .45 caliber Springfield rifle by the militia has caused renewed attention to be given to the improvement to be gained by the introduction of smokeless powder in caliber .45 ammunition. The present service cartridge uses 70 grains of black powder, with 500-grain lead bullet, and the standard muzzle velocity is 1,316 feet per second. The experiments now in progress contemplate the use of a smokeless-powder charge. They are directed to a selection of the most suitable smokeless powder, and perfecting the ammunition in other respects, on two propositions between which a choice can be ultimately made: (1) To simply substitute a charge of smokeless for the black-powder charge in the present cartridge which will give the same initial velocity. This would result in a reduction of the shock of recoil of the arm, whilst preserving its present well-recognized ballistic properties, particularly for long-range firing, and simplify the introduction of the ammunition in service, since no change would be required in the sights of the arm. (2) To reduce the weight of bullet to about 400 grains, and use a charge of smokeless powder adapted to give a muzzle velocity of 1,600 feet per second or higher. This would give greater flatness of trajectory up to a range of 1,000 yards, and by materially decreasing the weight allow a greater number of rounds to be carried per man. Its introduction would involve a change in the present rifle sights and perhaps an increase in cost of manufacture due to the possible necessity for jacketing the lead bullet.

SMOKELESS POWDER.

The Peyton powder at present manufactured by the California Powder Works and the Du Pont Company is now used for the .30-caliber service ammunition and is satisfactory. In addition to the contracts made with these companies for the supply of powder during the current year, a contract has been made with the Laflin & Rand Powder Company for a quantity to be delivered subject to test, and this company is now experimenting to produce a .30-caliber powder along the lines of its W-A powders. In previous tests this powder has shown excellent ballistic results, but produced undue erosion of the bore of the rifle. It has been found that the endurance of a rifle firing the Peyton powder will readily exceed 5,000 rounds, and the specifications

for the .30-caliber powder now include a test for erosion, under which "the erosion of the bore, after firing 5,000 rounds, must not materially exceed that exhibited by the rifle barrel No. 21244, which has been fired 5,000 rounds and will be retained at Frankford Arsenal as a present standard of reference." It is now also provided that each invoice lot of powder must be thoroughly blended by the manufacturer.

The exposure of service cartridges to the weather for a year's period in shallow open trays is now systematically pursued and constitutes a most severe test of their keeping qualities. Lots of cartridges made from different invoices of powder are taken from the factory and exposed in this manner. A portion of each lot is tested at the end of every four months. The tests made during the past year with the service powders confirm those previously reported. Although the loss of velocity from the exposed cartridges is sometimes considerable, the stability of the powder was not decreased, and when heated to 130° for twenty-four hours, to ascertain if the powder had been permanently injured, its ballistic properties were restored to be nearly the same as those of the original powder under the same treatment. The interior of the cases was not injured by contact of the powder during exposure and the primers of the cartridges remained unaffected. Two additional lots of the .30-caliber cartridges charged with Peyton powder and sent to Whipple Barracks, Ariz., for storage, in April, 1895, have been returned to Frankford Arsenal for examination, after storage periods of twenty-one and twenty-four months. These showed, when fired, nearly the same condition as those which had been stored for periods of three, six, and nine months, there being no material change from the original quality of the ammunition.

In the development of smokeless powder for .45-caliber ammunition a number of samples selected by the inspector of powder have been tested, and although promising results were obtained no selection has yet been made.

The policy of rendering every practicable assistance in the development of new smokeless powders has been pursued by the Department. Several pressure barrels and appliances for test of powder have been furnished by sale and all applicants invited to submit samples of their powder for test under the established specifications. The samples of experimental powders tested at the Frankford Arsenal during the past year have included a number for .30 and .45 caliber rifles from the Du Pont and the Laflin & Rand companies, tested for their information or for the information of the inspector of powder. In addition, the following have been tested and the reports of results are appended: Rottweil powder, for .30-caliber rifle; Savage Repeating Arms Company powder, for .30-caliber rifle, and Weidig powder, for .30 and .45 caliber rifles.

The samples of experimental powders tested at the Benicia Arsenal have included several for the .30-caliber rifle from the Giant Powder

Company and of "Italian smokeless," submitted by Mr. Gabriel, of San Jose, Cal., none of which have satisfied the requirements of the specifications. The results of these tests are included in the appended report from Benicia Arsenal.

MACHINE GUNS.

In March last a contract was made for 31 10-barrel Gatling guns, caliber .30, model 1895, with Bruce feed, and on September 9, 1897, a further contract was made for 18 additional guns of the same pattern. These guns are being manufactured by the Colts Patent Firearms Manufacturing Company, Hartford, Conn. The .45-caliber Gatling guns on hand and available for use in permanent fortifications have been collected at the Springfield Armory to be cleaned and repaired, when needed, and for the alteration to Bruce feed of all the older patterns originally made for the tin-case feed. Including the .30-caliber guns now under contract, about 200 .30 and .45 caliber Gatling guns are available for the fortifications. This is in addition to the .45-caliber guns distributed at different posts and required for service there. The .45-caliber guns at several posts in the Department of Texas which were fitted for the tin-case feed have recently been recalled and replaced by others fitted with Bruce feed.

To provide a movable mount for the machine guns in fortifications, one of the metallic carriages for machine guns, model 1890, has been fitted with defensive shields at the Sandy Hook Proving Ground, and is now undergoing test. The shield plates are made of hardened steel about 0.2 of an inch in thickness and were procured, shaped to the required form, from the Carnegie company. A design of casemate mount for the machine guns in fortifications has also been prepared.

ARMAMENT OF FORTIFICATIONS, ETC.

GUNPOWDERS.

Charcoal powders.—No new work in this line of powders has been entered on during the year, but the contractors have been engaged in furnishing brown and black powders under existing contracts. The probable early adoption of smokeless powder throughout our service reduces the importance of this branch of the subject, but it is nevertheless intended to have it on a systematic and well-organized footing, so that recourse to it could be had in case of necessity. The presses, plates, etc., necessary for the production of the entire series of powders required for the pieces in service are on hand and ready for use.

Smokeless powder.—It appears conclusive that when nitroglycerin is used under service conditions there appears to be no objection to its employment in powder, but that, on the other hand, there are decided advantages on the score of high ballistics and economy. These conclusions are drawn from general information and from the results of experiments with various smokeless powder compositions, as described

in my last annual report. These experiments, which were still in progress when that report was made, were completed during the year, except those involving long storage, and the results are only confirmatory of the conclusions derived from the earlier and principal portion of the series of experiments.

In order to investigate more fully the compositions composed essentially of nitrocellulose and nitroglycerin, and make the experiments with cannon powders for the service guns, three compositions were selected, all of the type designated "N N" (nitrocellulose-nitroglycerin), which are designated and described as follows:

N N (13-10); nitrocellulose yielding 13 per cent of nitrogen, the powder containing 10 per cent of nitroglycerin.

N N (12-25); nitrocellulose yielding 12 per cent of nitrogen, the powder containing 25 per cent of nitroglycerin.

N N (11-40); nitrocellulose yielding 11 per cent of nitrogen, the powder containing 40 per cent of nitroglycerin.

These compositions were regarded as including the practicable variations within the type, and as producing only allowable erosion and heating effects. The question of the form of granulation was also to be decided. The Maxim Powder and Torpedo Company succeeded in granulating a portion of the above range of compositions in their "multiperforated" form, which is regarded as possessing decided advantages, but those of the more india-rubber-like consistency had proved too refractory, and there seemed to be a question whether the composition most suitable in other respects would prove amenable to the most suitable granulation.

As granulation is a mechanical process, it was thought best to interest private manufacturers in the solution of the problem, and this course was adopted. Accordingly contracts were awarded to the Du Pont Company, Laflin & Rand Powder Company, and the California Powder Company for powder for field guns, 12-inch mortars, and 10-inch B. L. rifles. The compositions were prescribed as those stated above, but the form of granulation was left to the manufacturers. By this means it is expected to obtain comparison of the effects of these compositions in several forms of granulation strips, thin squares, tubular, and multiperforated. These powders are now being delivered and tested at the proving ground, and when the test of the series is completed, the results will, it is hoped, furnish sufficient information to warrant the adoption of approximately the most suitable composition and form of grain. While this investigation is mainly devoted to the "N N" type of composition, other types are not excluded, and orders have been given to the California Powder Works for a sample lot for the 8-inch B. L. rifle of the "Peyton" composition, to the Laflin & Rand Powder Company for a sample lot for the same gun of "W-A" composition, and one to the American Ordnance Company for a sample lot for 10-inch B. L. rifle of the most approved type of the Rottweil composition; also one to the

Du Pont Company for a special form of grain of the "N N" type. The manufacture of the above-mentioned powder had already progressed sufficiently to show that any of the forms of granulation described can be satisfactorily produced in each of the compositions prescribed, but the testing has not at this writing proceeded so far as to enable final comparisons to be made among the different compositions and forms of grain.

In connection with this subject it may be stated that the Department has endeavored, through its relations with private manufacturers, to further the development of the "multi-perforated" form of grain. The advantages of this form were first theoretically set forth by General Rodman, but it was impracticable to realize them in the charcoal powders. To the Maxim Powder and Torpedo Company belongs the credit of having revived the idea and applying it practically to the colloidal smokeless powder compositions. The results thus far obtained in the practical trials of powders of this form confirm the theoretical conclusions and indicate the ballistic superiority of this form over any other yet produced. Other considerations may in particular cases outweigh this ballistic superiority, and the definite determination of the relative values of the various conditions that affect the question is one of the principal objects of the experiments now in progress.

Satisfactory results have now been obtained with smokeless powders made in this country in all calibers of field, siege, and seacoast cannon, including mortars. This powder has also been found to give good results in the mortars when firing with reduced charges.

MANUFACTURE AND TEST OF POWDERS ON THE PACIFIC COAST.

Charcoal powders.—A lot of 40,000 pounds of saluting powder for the 3.2-inch and 3.6-inch rifled field guns, and a lot of 10,000 pounds for S. B. seacoast guns, have been manufactured during the past year by the California Powder Works. With this exception the only charcoal powders tested have been those submitted under the contract for brown powders for the 10 and 12 inch B. L. rifles, also with the California Powder Works, represented by Mr. Bernard Peyton. The requirements and results obtained with the powder for the 12-inch B. L. rifle, are as follows:

	Charge.	Projectile.	Velocity.	Pressure per square inch.	Remarks.
	Pounds.	*Pounds.*	*Ft. sec.*	*Pounds.*	
Requirements	490	1,000	2,025	38,000	
Actual results	490	1,000	2,111	40,835	Residue great in both cases. Accepted.
	465	1,000	2,043	37,350	

The first two sample lots of 10-inch powders submitted were not entirely satisfactory, being either too high or lacking in uniformity, but no trouble is anticipated in securing a powder for this gun at the

California Powder Works that will fully meet the requirements for service.

Smokeless powders.—No new smokeless powders have been submitted for test since my last report, though a number of lots similar to those previously submitted have been tested. The Giant Powder Company, which a year ago installed a testing plant at considerable expense, has abandoned the attempt to make a smokeless powder, although the last lot tested nearly fulfilled the Government requirements, failing only in the moisture test. It is believed that the powder made by the Giant Powder Works is nearly identical in composition with that made by the California Powder Works, and known as the "Peyton powder," but it has lacked the ballistic qualities of the latter through want of proper treatment.

After the receipt at Benicia Arsenal of the 3.2-inch B. L. rifle, adapted to metallic ammunition, several tests were made with powder furnished by the United States Smokeless Powder Company and the Giant Powder Company. None of these tests were, however, satisfactory. The single sample furnished by the Giant Powder Company gave results that were considered quite satisfactory. The results with this powder were as follows:

Date of test.	Charge.	Projectile.	Velocity at 100 feet.	Pressure per square inch.	Remarks.
	Ounces.	*Pounds.*	*Ft. sec.*	*Pounds.*	
April 16, 1897	12	16½	1,080	Less than 15,000.	
Do	16	16½	1,300	20,600	1 ounce black powder priming.
Do	18	16½	1,451	22,900	

The powders submitted by the United States Smokeless Powder Company were largely metallic salts of picric acid. The powder was in the form of dark-yellow spherical pellets, hard on the exterior, but breaking up easily when the outer skin was cracked. In the tests there always appeared a critical pressure below which the combustion was slow and incomplete, but above which the explosion was violent, with sudden and great rise in pressure without corresponding gain in velocity.

Proving ground at Benicia Arsenal.—Work on the new proving ground at this post was begun last fall by installing a 12-inch B. L. mortar, and preparing a firing butt by cutting into a hillside situated about 300 feet in front of the piece and laying bare a vertical wall of soft adobe rock to receive the projectile. The firing of the mortar caused the abandonment of the plan of installing modern guns of 8, 10, and 12-inch caliber at this point, but the installation of platforms, etc., for field and siege guns has been carried out.

During the wet season it was found that the marshy ground on which the target screens are placed becomes impassable, and a causeway has been run across from the guns to the butt. The platforms are now

arranged for field guns, for an 8-inch converted rifle, and for a 12-inch B. L. mortar, and if a pintle be placed for the siege carriages the latter can be used on the field-gun platform. Besides the butts, platforms, and target screens referred to there have been set up an instrument house of brick and a loading house of wood, each being protected by embankments.

SEACOAST GUNS.

Provision was made, in ordering the last sixty sets of forgings for 10-inch, 12-inch, and the type 16-inch guns, for the adoption of a new type of breech mechanism in which the several movements of rotating, translating, and swinging the breechblock are performed by a continuous movement of the operating handle in one direction. This mechanism has been applied to a 12-inch gun and found to work satisfactorily, no difficulty being experienced in operating it with one man, even when the gun was elevated about 10°. Considerable gain in power was shown over the old three-movement mechanism without reducing the speed of opening or closing the breech. The 12-inch rifle to which this mechanism is attached is known as the type gun of model 1896. In this model the tube is first hooped throughout its length, then a very long jacket is shrunk on, forming the third layer, and finally a fourth layer of hoops is applied over the breech. This construction gives somewhat greater tangential resistance to bore pressures than the service type, and much greater stiffness in the chase against bending or drooping. Owing, however, to the great length of the jacket, the facilities at the Army Gun Factory for uniformly heating it up for shrinking were inadequate, and considerable difficulty was experienced in assembling the gun. This mode of construction also has the grave disadvantage that in case the jacket should become fast on the tube before it has reached its home position it seems impracticable to remove it for the purpose of repeating the operation without rendering it useless. The tube of this gun is of nickel steel and was furnished by the Bethlehem Iron Company. The gun will be retained at Sandy Hook for current firings in connection with the test of powders, carriages, and projectiles.

Under the provisions of the fortifications act approved March 3, 1897, additional contracts have been placed with the Bethlehem Iron Company for ten sets and with the Midvale Steel Company for seven sets of 12-inch gun forgings, model 1895. The total number of sets of forgings thus far provided for, exclusive of type guns and the hundred guns contracted for with the Bethlehem Iron Company, are as follows:

Caliber of gun.	Number of sets.
8-inch	63
10-inch	87
12-inch	84

The number of guns completed up to June 30, 1897, was as follows:

Place of manufacture.	8-inch rifles.	10-inch rifles.	12-inch rifles.
Army Gun Factory	52	62	37
West Point Foundry	11		
Bethlehem Iron Works	25	15	
Total	88	77	37

In addition to the above, the Bethlehem Iron Company has ten additional 10-inch guns and five 12-inch guns nearly completed, under their contract for 100 guns.

Congress, by reducing the cost of gun forgings from 27 cents to 23 cents per pound, has reduced the cost per set about 15 per cent. It has been found practicable, also, to reduce gradually the cost of finishing and assembling at the Army Gun Factory about 20 per cent, thus making the total reduction in cost of the gun complete about 16 per cent. Of this amount about two-thirds is due to the reduction in cost of forgings and one-third to the cost of finishing and assembling. Of the reduction of cost made at the Army Gun Factory, about 60 per cent has been due to having on hand a considerable number of forgings, thus avoiding any interruption in the work, and to the working of a night shift. About 40 per cent was due to improvements in methods and system of manufacture. In order, therefore, to maintain the present low cost of manufacture, it is essential that adequate appropriations be made in advance, to provide that the requisite supply of forgings shall be on hand as needed.

The 16-inch gun.—A contract was entered into with the Bethlehem Iron Company, on December 30, 1896, for furnishing the Department with the forgings for a type 16-inch gun, under the provisions of the fortifications act of June 6, 1896. For the larger forgings—as the tube and jacket, and for the breechblock, which is very massive—the manufacturers have preferred to use nickel-steel, expecting thereby to obtain more readily the prescribed physical qualities than with ordinary gun steel. The substitution of nickel-steel has increased somewhat the cost of the forgings, which increase must, owing to the price limit imposed by the act of Congress, fall upon the manufacturers, unless Congress shall see fit to pass a measure for their relief. Some of the smaller forgings for this gun have been delivered and the ingots for the tube and jacket have been cast. All the forgings will be completed during the present fiscal year. Considerable preparations were required at the steel works in the way of ingot molds, etc., to permit of the manufacture of such large forgings as are required for this 16-inch gun. It is the intention also to reconstruct the heating furnace at the gun factory, in order to obtain sufficient capacity for a 16-inch jacket, for which purpose there is an appropriation available. To insure in advance the proper working of the breech mechanism for this gun, a dummy mechanism is under construction at the gun factory, a 15-inch smooth-bore

gun being utilized as the receiver of the breech mechanism for the purpose. The steel parts for this dummy will afterwards be utilized for the breech mechanism of the 16-inch gun itself, while the cast-iron block and breech casing can be used as gauges in the further manufacture of these guns.

SEACOAST MORTARS.

Under the provisions of the last fortifications act additional contracts for 12-inch mortar forgings have been placed as follows: With the Bethlehem Iron Company, for 36 sets; with the Midvale Steel Company, for 30 sets. The finishing and assembling of these mortars will be done at the following establishments: Builders Iron Foundry, Providence, R. I., 15 mortars; Niles Tool Works, Hamilton, Ohio, 15 mortars; Army Gun Factory, 36 mortars.

The total number of mortars thus far completed and under manufacture is as follows: Seventy-three 12-inch cast-iron hooped; one hundred and thirty-nine 12-inch mortars, steel, or a total of 212 mortars. All these mortars will be completed during the coming fiscal year.

SEACOAST CARRIAGES.

To replace the accidental and somewhat incorrect and confusing names for the service seacoast carriages that had grown into use during their experimental periods, and to avoid the serious mistakes that might arise therefrom, the following nomenclature for these carriages has been adopted, viz:

8-inch barbette, model 1892. (*a*)
8-inch disappearing, L. F.,* model 1894. (*c*)
8-inch disappearing, L. F.,* model 1896. (*d*)
8-inch disappearing, A. R. F.,* model 1896.
8-inch casemate, model 1894. (*b*)
10-inch barbette, model 1893. (*a*)
10-inch disappearing, L. F.,* model 1894. (*c*)
10-inch disappearing, L. F.,* model 1896. (*d*)
10-inch disappearing, A. R. F.,* model 1896.
10-inch casemate, model 1894. (*b*)
12-inch barbette, model 1892. (*a*)
12-inch disappearing, L. F.,* model 1896. (*d*)
12-inch disappearing, A. R. F.,* model 1896.
12-inch gun lift, model 1891.
12-inch casemate, model 1894. (*b*)
12-inch mortar carriage, model 1891.
12-inch mortar carriage, model 1896.
Barbette carriage for 8-inch muzzle-loading rifle, F. P.
Casemate carriage for 8-inch muzzle-loading rifle.
Barbette carriage for 15-inch smoothbore, F. P.

(*a*) This carriage has sometimes been called "nondisappearing."
(*b*) This carriage has sometimes been called "minimum port."
(*c*) This carriage is designed for a parapet that will permit a field of fire of 150°.
(*d*) This carriage is designed for a parapet that will permit a field of fire of 170°.
* The letters "A. R. F." stand for the words "all-round fire," and the letters "L. F." stand for the words "limited fire."

During the past year additional contracts have been placed for sea-coast gun carriages, as follows: With the Morgan Engineering Company, Alliance, Ohio, nine 8-inch disappearing carriages, L. F., model 1894; Providence Steam Engine Company, Providence, R. I., six 8-inch disappearing carriages, L. F., model 1894; Bethlehem Iron Company, South Bethlehem, Pa., ten 8-inch disappearing carriages, L. F., model 1896; six 10-inch disappearing carriages, L. F., model 1896; five 12-inch disappearing carriages, L. F., model 1896; Niles Tool Works Company, Hamilton, Ohio, six 10-inch disappearing carriages, L. F., model 1896.

Thus far the Department has been able to complete and furnish carriages as fast as the fortifications were ready for them.

DISAPPEARING CARRIAGES.

Disappearing carriages of the model of 1896, for guns of 8 and 10 inch caliber, have been completed and tested since the date of my last annual report. In these the expectations of the Department in regard to increased facility of maneuvering have been fully realized. In addition, the cost per carriage has been diminished about $1,000.

The completion and successful test of a 12-inch disappearing carriage is the most important event of the gun-carriage work of the year. It has heretofore been considered impracticable to mount guns of this size and power upon disappearing carriages, and more expensive and less convenient methods have been resorted to. The saving in expense of 12-inch batteries by the use of the disappearing carriage should be about one-half, while the rate of fire should be at least trebled, giving six times the efficiency for the same expenditure. Nine of these carriages are now under manufacture for issue to the service.

During the year the adopted disappearing carriage has received severe test at target practice in the hands of the troops. In some cases both officers and men have been absolutely without experience with the weapons used, and the complete success under such circumstances is very gratifying.

MORTAR CARRIAGES.

Contracts for additional mortar carriages have been placed during the year as follows: Providence Steam Engine Company, Providence, R. I., fifteen spring-return 12-inch mortar carriages; American Hoist and Derrick Company, St. Paul, Minn., fifteen spring-return 12-inch mortar carriages; Robert Poole & Son Company, Baltimore, Md., thirty-five spring-return 12-inch mortar carriages.

RAPID-FIRE GUNS.

Six-pounder R. F. guns.—Ten 6-pounder R. F. guns, with 250 rounds of ammunition each, have been furnished by the American Ordnance Company, tested and accepted by the Department. The carriages for

mounting these guns are now undergoing test. The carriage is of the type termed a "rampart carriage." When fired behind the parapet, it is rigidly attached to a pintle, and becomes in fact a fixed mount, thus admitting of a very rapid fire. When required for use in the open, as against landing parties, the mount takes the character of a simple field carriage, the recoil being checked by means of a trail spade.

Three-inch 16-pounder R. F. guns.—A new type of gun of 3-inch caliber and throwing a 16-pound projectile with a muzzle velocity of about 2,500 feet is now under study for adoption for the protection of mine fields in coast defense. This gun will be mounted on a fixed carriage, whether employed for rampart or casemate service. The rampart carriage will admit of lowering the gun behind the parapet, in order that it may be under cover when not in use. Funds are available for the purchase and test of a gun of this type, with these two different forms of mount.

Five-inch R. F. guns.—There are funds available for the purchase of from eight to ten 5-inch R. F. guns. A type gun of this caliber, consisting of a jacketed steel tube secured by a locking hoop, is just completed and is now ready for test. It is fitted with the Driggs-Schroeder breech mechanism. A second type gun, consisting of a solid forging cooled or tempered from the interior so as to produce the desired initial strains, is also nearly completed, and will be tested in comparison with the built-up gun. The single forging gun will be fitted with the Gerdom breech mechanism.

Six-inch R. F. guns.—A contract has been placed for the forgings for a 6-inch R. F. gun of .45 calibers length of bore, and throwing a 100-pound projectile with a muzzle velocity of 2,500 feet.

The question of mounting guns of smaller caliber than 8 inches arranged for rapid fire is of importance. The present mounting for the 5-inch R. F. gun is a barbette carriage placed upon a balanced pillar, the gun when out of action being concealed behind the parapet. For use the gun is run up by hand and remains exposed while in action. The type has been successfully tested, and eight mountings are now under manufacture for issue to the service. It is questioned whether the disappearing carriage is not a more satisfactory mounting for guns even as small as the 5-inch, and it is considered quite probable that for larger calibers it will prove so.

The Department has under construction a disappearing carriage for a 6-inch R. F. gun, arranged to meet the conditions of that class of service, and from the result of its tests conclusions can be drawn as to the advisability of the use of the type for smaller calibers. It is believed that the disappearing carriage will give nearly the same rapidity of fire as the pillar mount, and it is known that it will give much better protection to both gun and gunners and will cost less than the pillar mount.

PROJECTILES FOR SEACOAST SERVICE.

Under the provisions of the last fortifications act, a contract was placed with the Tredegar Iron Works Company, Richmond, Va., for the following cast-iron projectiles: Two hundred 8-inch shot, three hundred 12-inch shot, six hundred and four 12-inch mortar shell; and with the Rome Locomotive and Machine Works, Rome, N. Y., for cast-iron projectiles as follows: Three hundred 10-inch shell, and five hundred 7-inch shell.

A contract was also placed with the Driggs-Seabury Ordnance Company, Derby, Conn., for the following steel projectiles: One hundred and ninety-five 8-inch A. P. shell, six hundred and five 10-inch A. P. shell, one hundred and fifty 12-inch A. P. shell.

As regards cost, the prices on which the contracts were made were low, and in that respect were very satisfactory.

FIELD ARTILLERY.

3.2-inch field guns, service.—Contracts for 110 sets of forgings for 3.2-inch guns have been placed during the year; some of these guns have been completed and others are now being assembled at the gun factory. About 100 of them will be chambered for smokeless powder; the remainder, and eventually all the 3.2-inch guns now in service, will be similarly chambered, a short lining tube being inserted at the breech to admit of this modification. The carriages for mounting these additional guns, with their complement of caissons and battery wagons and forges, are being manufactured at the Rock Island Arsenal.

Experimental firings with the Gerdom, Dashiell, Fletcher, and Seabury 3.2-inch field guns, adapted for using metallic ammunition, are still in progress.

3-inch field gun, experimental.—At the time the present 3.2-inch field gun was designed and introduced into service, some fifteen years ago, it was thought to meet all essential requirements, and was proved to be, in fact, fully equal to the best field gun extant at that period. Since that time, however, the introduction of smokeless powder and some improvements in the construction of the gun and its carriage, have made it practicable to increase the power and efficiency of this piece without sacrificing requisite mobility. Accordingly, the Department has had under study for sometime a reconstruction of the present design of its field gun and carriage. With this in view a gun has been designed of 3-inch caliber and 28-calibers length of bore, weighing about 839 pounds. This piece will have greater power than the present 3.2-inch field gun, as its projectile will weigh 15 pounds and have a muzzle velocity of about 1,600 feet per second, the velocity being determined with regard to the effect of shrapnel at 3,500 yards. At this range, in order to inflict dangerous wounds upon horses, the energy of the shrapnel bullets should be about 282 foot-pounds. This requires

for the smallest-sized bullets, viz, 42 to the pound, a remaining velocity of about 874 feet per second, which would correspond to a muzzle velocity of about 1,600 feet.

Owing to its higher muzzle velocity and greater sectional density, this 15-pound projectile would have higher remaining velocities at all ranges, and thus a flatter trajectory. But the remaining velocity is of greater importance in another respect. The shrapnel bullets must have a certain striking energy to be effective. If the remaining velocity is increased, the weight of the bullets and fragments can be decreased, and so their number increased for a given weight of projectile. Thus, as respects the remaining velocities of the 3.2-inch 16½-pound and of the 3-inch 15-pound projectile, there is an advantage, on an average, of about 6 per cent in favor of the 3-inch projectile for ranges up to 3,500 yards. We shall then have an advantage of 12 per cent in energy for the same weight of bullet, and we can thus reduce the weight by 12 per cent in this projectile and retain for the bullets the same striking energy as for the heavier bullets in the 3.2-inch projectile. That is, if we should reduce the weight of all the parts of the 16½-pound shrapnel so as to get a 15-pound 3-inch shrapnel of the same number of parts—which is a reduction of about 9 per cent—we should obtain as many pieces, each striking with greater energy, and, moreover, being of less dimensions, having greater penetration for the same energy. Hence, the effectiveness of a single 15-pound 3-inch projectile would be about the same or a little greater than that of the 16½-pound 3.2-inch projectile. The higher velocity imparted to the 15-pound 3-inch projectile, owing to the use of smokeless powder and an improved design of gun carriage, is permissible.

The principal advantages, then, in favor of the proposed 3-inch gun over the present service 3.2-inch gun are greater flatness of trajectory, giving increased length to the danger spaces, higher remaining velocity, and greater energy of impact at all ranges and a lighter and yet equally effective shrapnel, cheaper and more convenient to handle and load, and which will permit of carrying 132 more rounds per battery of six guns, with an estimated decrease in weight of only 8½ pounds in each ammunition chest.

Two 3-inch guns, designed as above described and having the same ballistic power, are now under manufacture, one to consist of a jacketed forged-steel tube, and the other of a single forging, which, after being rough-finished, is heated and then cooled from the interior, in order to obtain the initial tensions requisite for tangential strength. The test of these guns will furnish useful information touching their relative endurance and cost of manufacture.

Three-inch field carriage, experimental.—A carriage will be required for the 3-inch gun differing materially from the 3.2-inch carriage now in service. The design for this carriage is receiving much study and attention, as it is proposed to take up, in connection with the design, the subject of an effectual means for checking the recoil.

The recoil of our modern type guns is so great that the brakes heretofore used on the wheels of the carriage do not furnish sufficient resistance to recoil. The long time required for running the carriage a long distance back into battery after discharge prevents a sufficiently rapid service of the piece. Moreover, the great weight of the trail makes the labor of running the carriage back into battery so great as to soon exhaust the cannoneers. The Department has already made sufficient experiments with the spade in the end of the trail to determine both its efficiency and the construction desired. This involves the use of a recoil cylinder, interposed between the gun and the carriage. The Department has also obtained sufficient information and data, by experiment, for this construction, and it does not involve serious difficulty except that it must add both weight and complication to the carriage, which are objectionable, though necessary to the method. This method, however, relieves the carriage from so much of the strain of recoil that the carriage can probably be so much lightened as to compensate for the additional weight of the recoil cylinder and cradle in which the gun must be mounted. A more serious matter, however, is that if the spade is used it is so embedded in the ground by the recoil as to make pointing of the gun by traversing the carriage extremely difficult, if not inadmissible, on account of the time consumed therefrom.

To meet this almost prohibitory objection, carriages have been constructed to provide a small traverse of the gun itself on the carriage. This is effectual, but adds so much to weight, and especially complication, that it is feared it would not be admissible in our service, even though it might be admissible in some foreign service. In time of war our batteries must be manned and served suddenly by raw troops, and endure service over the very roughest country. The additional weight that provision for traversing involves is objectionable, even though it should be partially or even entirely compensated for by the reduction in weight of carriage above mentioned. The more serious objection of the complicated mechanism, however, could not be avoided. A thorough study, therefore, is being made of other means for checking the recoil than the spade, and especially of means for so anchoring the carriage that it can be pointed by traversing the trail, and also of introducing the recoil cylinder between the anchorage and the carriage, so as to utilize the inertia of the carriage, as well as that of the gun, in checking the recoil. Opposed to this method is the fact that it still subjects the carriage to all the strains of recoil as in our present carriage, and the carriage can not be lightened as mentioned above. Another objection to the spade is that it enhances the very objectionable jumping of the carriage in recoil. It is hoped, in the construction and test of this new gun and carriage, that a satisfactory solution for our service of this very troublesome question of checking the recoil can be arrived at. Its importance is appreciated.

FIELD AND SIEGE PROJECTILES.

The orders placed for manufacture during the year 1897–98 comprise a limited number of 3.2-inch canister, and common shell, 3.6, 5, and 7-inch shrapnel, and fuses as needed for issue to the service. The 3.6-inch shrapnel now being made will differ slightly in design from those described in the last annual report. In order to burst the case more effectively, the bursting charge, which was contained in the head only, is partly distributed as a central charge in a 0.5-inch tube, extending nearly to the base. The change has reduced the number of balls from 218 to 210, and the total number of pieces in the shrapnel from 276 to 267. The American Ordnance Company completed its deliveries in March last of the 4,000 3.2-inch shrapnel under contract of September 4, 1896. These shrapnel are made with a case of seamless drawn steel tubing, containing about 0.72 per cent of carbon, which, after being subjected to firing tests, was accepted as a proper substitute for the lap-welded steel tubing used in the manufacture of similar shrapnel at the Frankford Arsenal.

The 3.2-inch field guns of model 1890 M, now being made for a smokeless-powder charge, will use a 16.5-pound projectile, with band 0.625 of an inch from the base. Experiments have been made to determine the practicability of changing to this position the band of the 16.5-pound shrapnel on hand which were originally made with the band 1.75 inches from the base. The results of these tests, which have included firings through a 4-inch wood target into the sand butt, from which the shrapnel were recovered for examination, besides target practice and comparative firings, to measure the cone of dispersion, have shown that the position of band may be changed as required without material detriment to the serviceability of the shrapnel. A report of the firings and the targets made in the dispersion tests is appended. The results furnished interesting data on this subject for our service shrapnel. At a range of 1,000 yards the cone of dispersion of the shrapnel from the point of burst is about 16 degrees, which will cover a circle about 23 feet in diameter at a distance of 27 yards. The number of balls and fragments of the shrapnel contained within this cone of dispersion is about 260 for the 13.5-pound and 280 for the 16.5-pound shrapnel. These shrapnel contain in their make-up a total of 200 and 236 pieces, respectively. The increased number of pieces arising from the burst is due to the fragmentation, principally, of the case and the cast-iron separators which are placed between the layers of hardened lead balls. The dispersion of the shrapnel increases with the range. From previous experiments the angle of dispersion for the shrapnel burst within 50 yards of the muzzle of the gun was found to be about 12 degrees.

Although a majority of the fragments of the separators in the present shrapnel will penetrate an inch of pine at a distance of 30 yards or more from the point of burst, yet a portion of them, being small and

of irregular shape, are simply embedded and would hardly inflict a dangerous wound. The Department is now experimenting with a new type of 3.2-inch shrapnel without these separators, but which will contain an increased quantity of hardened lead balls, with the object of obtaining a greater number of regularly shaped and effective fragments. Some firing tests have been made of these to test the resistance of compression and deformation offered by the bullets. The tests were fairly satisfactory, and it is thought that all defects can be eventually overcome and an improved shrapnel obtained.

Sample shrapnel made for the 5-inch rapid-fire gun, fixed ammunition, are now awaiting test. This shrapnel weighs 55 pounds and contains 382 hardened lead balls of 166 grains each, with separators, etc., making a total of 478 pieces. The design is similar to that of the 5-inch shrapnel for siege guns, described in the last annual report, with a head-bursting charge of 12 ounces, partly distributed in a central tube. The position of band is changed as required for fixed ammunition, and the weight is 10 pounds greater, giving an increased number of balls and fragments.

METALLIC AMMUNITION FOR FIELD GUNS.

Experiments with metallic cases during the year have been confined to a design of 3.2-inch case proposed by Lieutenant Dunn, of the Ordnance Department, comprising an open drawn case for the body, with a detachable base and rubber ring to seal the escape of gas. The purpose of the design was to use aluminum for making a light serviceable case and obviate the manufacturing difficulties heretofore encountered in attempting to make a solid drawn case of this metal. The cases tested by firings at the proving ground comprised five of the aluminum body and base and one body of brass with bronze base and also with an extemporized brass base. The results showed that the base made of hard brass only would resist deformation and prevent spreading of the primer pocket, etc. And whilst a certain degree of serviceability might be expected from a perfected case on this design, made with an aluminum body and hard brass base, it would still not compare favorably with the solid drawn brass case for use in service.

The manufacture of metallic ammunition for field artillery has been discontinued. My annual reports for several years past show that much attention has been paid to the subject of metallic ammunition for field guns, that satisfactory metallic cases and ammunition, and a plant for their manufacture, have been perfected, and that a small quantity of the ammunition has been fabricated. The plant is required for manufacturing metallic ammunition for our rapid-fire guns. A satisfactory breech mechanism for this ammunition has also been arrived at, although, as stated in another part of this report, some experiments for further improvement of this mechanism are still in progress and will be completed.

Some late experiments show that the benefit of paramount importance attained by the use of the metallic case, viz, keeping the powder dry for field artillery, can be attained in another way, and that the serious objections to the metallic ammunition can therefore and thereby be avoided.

The advantages and disadvantages of the metallic ammunition for field service may be briefly summarized as follows:

Advantages.—First. The great and important advantage, as has been stated, is that the metallic case perfectly protects the powder from water and moisture. This ammunition may be left for a long time immersed in water without injury to the powder or effect upon its ballistic qualities. It is well known that our powder charge has been heretofore packed in wool or silk bags. These were packed in the ammunition chests with tow to protect them from injury from jolting. Batteries with this ammunition could not cross streams of such depth that the water would rise to the ammunition chests without the construction of bridges. As great if not a greater objection to the cartridge-bag ammunition was that when the ammunition chests were exposed for a long time in falling or damp weather the powder was so deteriorated as to materially diminish velocities and ranges. This defect would practically neutralize the advantages of the perfect accuracy of our modern breech-loading rifled guns and the absolute perfection in rate of burning of the time fuse, as well as diminish the power of the gun and its ammunition. On this account the metallic case appeared to be a necessity, notwithstanding its many disadvantages.

Second. The metallic case is a perfect gas check and overcomes the necessity for the gas check now in use and some requirements in the breech mechanism to provide for it.

Third. An advantage claimed for the metallic ammunition has been that it would permit more rapid fire. This is questionable, because the second or so additional time required for inserting the round in two parts disappears in the long time required for running the gun back into battery, and the longer time which efficiency demands should be expended in accurate aiming and determination of range, ordinarily.

Disadvantages.—The disadvantages are numerous; among these are—

First. Increased cost of ammunition.

Second. Increased cost of breech mechanism, and increased complexity of the same and its liability to get out of order.

Third. No matter how perfect the mechanism, the liability in the heat of battle that a case may stick or become jammed, from accident or other cause, in the bore and the gun made useless.

Fourth. The metallic case must have a sensitive primer in direct contact with the powder charge in the ammunition chest. The violent shocks to which ammunition is subjected in the ammunition chests, no matter what precautions are taken for protecting primers, cause grave apprehensions that serious accidents will be possible. Even if safe

from accidents from this cause, the ammunition chest is always liable to be struck in battle and the primer cause a serious explosion. Without the primer the smokeless powder is probably safer from such accidents than the old black charcoal powder.

Fifth. Increased weight of ammunition. This is the great and important objection. It subtracts 132 rounds from the number that may be carried by a six-gun battery.

As has been stated, the necessity for protecting the powder from moisture was so imperative, however, as to overrule all the disadvantages mentioned.

Experiments concluded during the past year have been successful in proving that the powder charge can be perfectly protected, both from moisture and when submerged in water, by a waterproof cover, which can be quickly removed before inserting the cartridge in the gun.

On this account, as has been stated, the manufacture of metallic cases has been stopped, and it is not probable that they will be used in field service, although the Department will at all times be prepared to take up its manufacture and to introduce into the guns on hand the changes in the breech mechanism required for its use.

TELESCOPIC SIGHTS.

Steps are now being taken to supply telescopic sights for the seacoast guns. Thirty Scott sights have been procured and seventy more ordered for this purpose. Provision is made for using these sights on brackets placed in either one of two positions, namely, on the right trunnion of the gun, where the sight may be used for giving elevation as well as direction in firing, and on a sight standard placed on the chassis at the rear of the carriage, where it is available for giving direction alone in firing.

The instructions which have been prepared for the inspection of telescopic sights are herewith appended.

CHANGES IN MATERIAL.

Oiler for magazine arms.—The magazine rifles and carbines of model 1896 are furnished with a small oiler of brass, nickeled, which is carried with the sectional cleaning rod in the butt of the stock. The oiler is to contain cosmoline oil for lubricating purposes. Its shape permits it to be carried also in a loop of the cartridge belt, and at present, for the arms in service which are not adapted for carrying it in the butt, the oiler is issued to each noncommissioned officer with troops, to be carried in the belt. (See General Orders, No. 51, Adjutant-General's Office, 1896.)

Breech-mechanism covers for magazine arms.—As a result of the field trials referred to in the last annual report, a detachable covering made of brown canvas, to be fastened with a leather string, has been provided for the service and was described under the head of "Equipments" (page 8).

The cover is not expected or intended to obviate the usual cleaning and care required to keep the mechanism of the arms in good condition for service at all times. The cover can be very quickly removed to use the arm for firing in an emergency, and its light weight and little bulk readily enables it to be carried on the person of the soldier on the march, when not carried on the firearm. (See General Orders, No. 23, Adjutant-General's Office, 1897.)

Bayonet scabbard.—The bayonet scabbard has been provided with a "stop" at the attachment of the loop to the sheath, which prevents the latter from turning upward to a position in which the bayonet could drop out. This change, which can be applied by altering the scabbards on hand, has been made in consequence of reports from the service that the bayonet would sometimes be lost from the scabbard in rapid maneuvers, particularly on bushy ground.

Magazine cut-off, .30-caliber arms.—The operation of the present cut-off, in which the thumb piece is turned up to hold the cartridges in the magazine in reserve whilst using the arm as a single loader, has been found to be disadvantageous, particularly for cavalry service. In this position the thumb piece is exposed and forms a projection from the arm which renders it liable to be broken by accident. A new pattern of cut-off has been devised which reverses this motion. It can not be applied to arms now in service, since it embodies also some alteration of the receiver, but will be adopted in future manufacture. By this alteration the thumb piece of the cut-off will be turned down to stop the passage of cartridges from the magazine, and, being habitually carried in this position, it will be better protected than before.

Smokeless-powder charges for 3.6-inch field mortar.—As announced in General Orders, No. 18, Adjutant-General's Office, 1897, charges of smokeless powder have been substituted for the sphero-hexagonal powder at first adopted for the service of this piece. The four charges of smokeless powder, which are numbered and marked on the cartridge bag from one to four, inclusive, are respectively made to give nearly the same velocity as the corresponding charges (4, 6, 10, and 16 ounces) of sphero-hexagonal powder designated in the range tables dated August 2, 1895, so that no changes in the tables are required. The weights of smokeless-powder charges are, approximately, $1\frac{3}{4}$, $2\frac{5}{8}$, $3\frac{7}{8}$, and $5\frac{11}{16}$ ounces, with an igniting charge of one-fourth ounce of black rifle powder. These give more uniform results for velocity and range than the former charges of black powder. But, like the latter, and as might be expected in view of their smallness, are very sensitive to differences in weight which may arise in making up the charges. This, combined with the variety of charges and the shortness of bore, which allows a part of the charge to be sometimes thrown out unconsumed, renders it difficult to obtain accurate ranges in the service of the mortar. The smokeless powder at present in use is the service .30-caliber small-arms powder. Experiments are in progress which may result in the adop-

tion of a smokeless powder of different granulation or composition, giving further improvements in ballistic results.

Gunner's quadrant.—The gunner's quadrant now issued is designated "Model 1892, modified." The changes made from the model 1892 (see Plate IV, Appendix 32, Report of the Chief of Ordnance, U. S. A., 1892) comprise a stronger and materially stiffer frame and a level of increased length. A scale of minutes is placed on the glass of the level to facilitate the centering of the bubble and enable slight angles of inclination to be read from the position of the bubble when not centered.

I have the honor to submit herewith the following papers as appendices to this report:

Appendix 1.—Report of action taken during the year ending June 30, 1897, under the provisions of the act approved March 3, 1881.

REPORTS FROM ROCK ISLAND ARSENAL.

Appendix 2.—Report of principal operations (1 plate).

Appendix 3.—Report on extraordinary repairs and improvements of dikes and dams of Rock Island water power (7 plates).

Appendix 4.—Report on the manufacture of saddletrees (3 plates).

Appendix 5.—Report on foundations of Shop G (1 plate).

REPORTS FROM SPRINGFIELD ARMORY.

Appendix 6.—Report of principal operations.

Appendix 7.—Firings of .30-caliber rifle and carbine.

REPORTS FROM FRANKFORD ARSENAL.

Appendix 8.—Manufacture of small-arm ammunition.

Appendix 9.—Utility of tinning cartridge shells.

Appendix 10.—Tables of fire .30-caliber magazine rifle and carbine.

Appendix 11.—Effect of temperature on velocity of .30-caliber ammunition (2 plates).

Appendix 12.—Deviation of small-arm projectiles due to artificial wind pressure (5 plates).

Appendix 13.—Tests of smokeless powder for small arms.

Appendix 14.—Report of chemical laboratory.

Appendix 15.—Reloading tools for 1.65-inch mountain gun (3 plates).

REPORTS FROM WATERVLIET ARSENAL AND ARMY GUN FACTORY

Appendix 16.—Report of principal operations (4 plates).

REPORTS FROM WATERTOWN ARSENAL.

Appendix 17.—Report of principal operations.

Appendix 18.—Report on a striding clinometer for graduating the elevating circles of gun carriages (1 plate).

Appendix 19.—Specifications for an electric-lighting plant at Watertown Arsenal.

MISCELLANEOUS.

Appendix 20.—Instructions for inspection of telescopic sights.

REPORTS FROM ORDNANCE PROVING GROUND, SANDY HOOK, NEW JERSEY.

Appendix 21.—Report of principal operations.
Appendix 21a.—Summary of tests of smokeless powders.
Appendix 22.—Cone of dispersion of shrapnel (19 plates).

REPORTS FROM BENICIA ARSENAL.

Appendix 23.—Report of principal operations.
Appendix 24.—Tests of charcoal and smokeless powders.

MANUFACTURE OF POWDERS.

Appendix 25.—Report of the inspector of powder.

CONSTRUCTION OF ORDNANCE.

Appendix 26.—Progress report of the inspector of ordnance on the manufacture of steel forgings, castings, etc., for guns and carriages, at the Midvale Steel Works, Philadelphia, Pa.

Appendix 27.—Progress report of the inspector of ordnance on the manufacture of steel forgings, castings, etc., at the Bethlehem Iron Works, South Bethlehem, Pa.

Appendix 28.—Progress report of the inspector of ordnance on the manufacture of mortar carriages at the works of the Robert Poole & Son Company, Baltimore, Md.

Appendix 29.—Progress report of the inspector of ordnance on the manufacture of ordnance material at the Kilby Manufacturing Company, Cleveland, Ohio; the Niles Tool Works Company, Hamilton, Ohio; the Morgan Engineering Company, Alliance, Ohio; and at other works.

I have the honor to be, very respectfully,

D. W. FLAGLER,
Brigadier-General, Chief of Ordnance.

The SECRETARY OF WAR.

APPENDIX 1.

Report of action taken during the year ended June 30, 1897, under the provisions of the act approved March 3, 1881.

NOTE.—No purchases or sales have been made during the year.

APPENDIX 2.

ANNUAL REPORT OF THE PRINCIPAL OPERATIONS AT ROCK ISLAND ARSENAL.

(1 plate.)

ROCK ISLAND ARSENAL,
Rock Island, Ill., July 31, 1897.

SIR: I have the honor to report as follows regarding the principal operations at this arsenal during the fiscal year ending June 30, 1897:

By Special Orders, No. 51, Adjutant-General's Office, of March 3, 1897, I was placed in command of the arsenal, relieving Col. A. R. Buffington, Ordnance Department. Before that date, under his direction, the completion of the bridge over the Mississippi River between this island and the city of Davenport had been brought, in the fall of 1896, to a successful conclusion. A full report of this work was made by him under date of March 10, 1897.

Under his direction also the openings in the upper end of the Moline dam wall were closed, and the whole water power privilege heretofore used and unused by the Moline Water Power Company concentrated at the junction of the stone and earthen dikes at the east end of Sylvan Island, a new concrete dam with openings being constructed for this purpose at that point. Lieut. Odus C. Horney, Ordnance Department, was in direct charge of this work, and his report concerning it is herewith appended (marked Appendix 3).

The original plan contemplated, after closing the openings, placing a retaining wall in rear of the old Moline dam wall to secure the arsenal water power against destructive accident or injury that might otherwise be caused by high water or freshets in the Mississippi River, but the unexpected cost of the work and of certain repairs to other dams and dikes provided for by the same appropriation compelled the cessation of work last December for lack of funds, the appropriation being entirely exhausted before any of this embankment had been constructed.

Some unusual precautions therefore became necessary during the period of high water in April and May of this year, which, as the full-flood stage of the river was not reached, proved sufficient to afford the necessary protection.

Congress has since by an appropriation approved June 4, 1897, granted a sum which will permit the construction of the retaining embankment to a height above the most extreme flood record, and the strengthening of the wall so that the necessity for future repairs should not arise for many years. It is proposed to take the material required from certain bars that have formed in the water-power pool or from the bottom of the pool itself, thus obtaining also a much-needed betterment of the water power.

By an act approved June 11, 1896, Congress appropriated $2,000 for painting the Rock Island Wagon Bridge and the Moline Bridge, and $1,175 for renewing the wood floor of the latter. The former bridge was painted in the fall of 1896. In the spring of this year the latter work was taken in hand, the old floor stringers which were much decayed removed and replaced by new, some of wrought-iron beams and some of wood, and a new floor planking laid. All the ironwork of the bridge was at the same time given two coats of paint.

Throughout the island a careful cleaning up was made this spring; the surface was also thoroughly burned, destroying the dead grass, branches, and other accumulation. The roadways and their gutters between and back of the shops were also cleaned and put in good condition.

The east steps of Shop G, which had settled somewhat, were taken down and rebuilt, and the bridge over the artificial lake north of the shops was repaired and placed in condition for use.

The old pump employed to fill the high tank from the main reservoir being unequal to the work required, was replaced by a larger and better one, which it is not necessary to run more than eight hours per day.

As previously stated, the Rock Island Bridge was completed last fall. It has been in regular use since that time and has proved to be a most admirable structure. The traffic from January 1, 1897, to June 30, 1897, is given in the following table:

	January.	February.	March.	April.	May.	June.	Total, 6 months.
Engines, north	86	67	96	94	83	78	504
Engines, south	60	63	69	71	56	56	375
Engines with trains, nor	673	611	693	673	739	711	4,100
Engines with trains, sou	707	630	722	713	730	741	4,243
Passenger cars, north	1,364	1,240	1,403	1,401	1,432	1,445	8,285
Passenger cars, south	1,384	1,242	1,422	1,418	1,415	1,400	8,281
Freight cars, north	7,706	7,550	9,095	8,621	8,631	9,874	51,477
Freight cars, south	7,931	7,757	8,517	7,726	9,441	9,794	51,166
Street cars, north	2,550	2,548	3,255	3,180	4,695	4,830	21,058
Street cars, south	2,945	2,550	3,286	3,255	4,710	4,620	21,366
Teams, north	18,104	14,560	20,491	25,905	25,110	25,530	129,700
Teams, south	18,104	14,060	20,522	24,990	26,288	25,350	129,314
Pedestrians, north	32,643	19,208	24,335	34,680	31,403	30,360	172,629
Pedestrians, south	32,612	19,292	24,111	34,380	32,550	30,576	173,521
Steamboats, up river			25	180	241	254	700
Steamboats, down river			29	174	247	258	708
Barges, up river			4	26	50	52	132
Barges, down river			8	33	33	77	151
Rafts down river			4	52	91	73	220
Strings of logs, down river			29	417	815	741	2,002
Strings of lumber, down river					74	59	133

It is probable that some of the minor details of the mechanism for moving the draw may have to be strengthened or further adjusted, but the work will not be necessary before the close of navigation next fall.

The painting must be renewed at the earliest possible date, it having entirely worn off in some of the more exposed places and being in poor condition throughout. An estimate for this work is submitted herewith. (See Enc. 5 of 9468.)

Except the repairs imperatively necessary nothing has been done to the floor stringers and planking of the Rock Island wagon bridge for some years, and they have now reached a condition when a thorough overhauling and replacement should be made. An estimate for new floor stringers and planking is submitted herewith. (Enc. 5 of 9468.)

It is seven years since any extensive repairs were made to the arsenal railroad, and as a consequence many of the ties are now badly decayed and the road can only be used with extreme care. The entire roadbed should be carefully gone over and the majority of the ties replaced. An estimate for such work is submitted. (Enc. 5 of 9468.)

The buildings which have been used for many years as post hospital and upper and lower stables are old frame structures originally erected as temporary barracks during the civil war, about thirty-five years ago, when the island was occupied as a post for prisoners of war. They are all, especially the former, unfit for the purposes to which they are now put. It is almost a cruelty to a patient to send him for treatment to such a building, the like of which probably does not exist at any other military post. The inspector-general of this district, in his report of a recent inspection of the post, states "The hospital is an old frame building, utterly unfit for hospital purposes, and not worth repairing." It is recommended that an effort be made to obtain an appropriation for new hospital and stables. Estimates have repeatedly been submitted, and they are again included this year. (Enc. 5 of 9468.)

During the fiscal year a large amount of infantry equipments, cavalry accouterments, horse equipments, materials for target practice, artillery harness, carriages, caissons, projectiles, ammunition, and many other articles of ordnance stores were issued to the Army, colleges, and militia, and a quantity of similar articles, in an unserviceable condition, were turned in here to be repaired or broken up. New articles were also received on purchase to be used in manufactures or for issue.

The amount of these transactions is exhibited in the following table:

Receipts of ordnance stores.

From Army, militia, and sundry persons.................. 383 lots, 437,140 pounds.

Issues of ordnance stores.

	Lots.
To the Army	1,609
To the militia	184
To sundry persons	147
Sales	223
Total (weight, 1,914,630 pounds)	2,163

The manufactures at the arsenal during the year have been of two general classes, the various articles of infantry equipments, cavalry accouterments, horse equipments, and other similar ordnance stores, which were made to a value of $235,571.89, and field-gun carriages, limbers, caissons, battery wagons and forges, 5-inch siege carriages, 7-inch howitzer carriages, siege limbers, with the necessary implements and equipments for the artillery service, and repairs to the same and to Gatling-gun carriages and limbers, all to a value of $182,713.78, or a total value for articles manufactured of $418,285.67.

In addition a large amount of work was done on field and siege carriages, which are still in hand and will not be completed until late this fall. The force employed, which was considerably increased during the last months of the fiscal year, numbered 550 employees of all grades at its close.

There was no particular novelty about any of the fabrications except in the case of the saddletrees and the breech mechanism covers for caliber .30 magazine rifle and carbine.

For many years the old saddles here in store left over from the supply purchased during the war were dismantled as new were required, the trees repaired and then covered, and the saddle completed. This supply was, however, finally exhausted about a year ago, when it became necessary to make new trees.

The former commanding officer of the arsenal placed the supervision of this work in the hands of Lieutenant Horney, Ordnance Department, who devised some of the methods and whose report upon the fabrication of the trees is herewith appended (marked Appendix 4).

The breech mechanism covers were first made of black enameled cloth, and 1,000 were issued for trial by June, 1896. The reports from the field showing that the cover, both as regards material and shape, was not entirely satisfactory, I submitted to you a new sample in April, 1897, which being approved, 15,350 were made and issued to the Army by the close of the fiscal year.

The cover made of the No. 9 drab cotton duck used for the haversack is sewed with No. 30 drab linen thread and secured over the breech mechanism by two thongs of lace leather. For manufacture it is cut in three pieces of the form shown in Pl. I, which when assembled have portions fitting over the trigger guard and bolt handle, and the end of the bolt and the cocking piece; the long string at the front is wound round the cover and tied with the short one at the rear end. The fold is well down on the side of the rifle and so placed as to prevent the entrance of moisture.

For 100 covers, 21½ yards, 36½ inches wide, of the cotton duck, one-fifth pound of thread and 1¼ sides lace leather are required. The cost is $20 per hundred.

The buildings in regular use for manufacturing purposes are Shop C, the combined carpenter, harness, and machine shop, and Shop E, part of which is used by the foundry and forging shops. In the former the basement and first floor are occupied by the machine shop, where not merely all metal work forming part of the large annual fabrications of infantry equipments, cavalry accouterments, and horse equipments must be conducted, and also the large amount of machine work in repairs, but all the manufacture of field and siege carriages, limbers, caissons, etc.. as well. For this double purpose both the building and the plant therein are totally inadequate to the expeditious and economical prosecution of the work, especially that of the latter class.

The plan of the arsenal contemplates the equipment of Shop G as a siege carriage manufactory and the time has certainly arrived for its development. Estimates are submitted for preparing the basement and first floor of the west wing of Shop G for the reception of machinery and for the purchase and installation of some machines particularly adapted to work on siege carriages; if granted this will allow more of the plant now in Shop C to be limited to field carriage work, considerably enlarging the output of such carriages as well as those mainly to be fabricated in Shop G.

In the latter shop as additional funds might be provided the proposed siege plant could be extended to the full extent of the east as well as the west wing and more of Shop C could be employed on field carriages. This would ultimately give a plant adequate to the production annually of 30 carriages and limbers for the 5-inch siege gun, 30 carriages

and limbers for the 7-inch howitzer, and a like number for the 7-inch mortar, and also carriages, limbers, caissons, etc., sufficient for 40 field-gun batteries of 6 guns each.

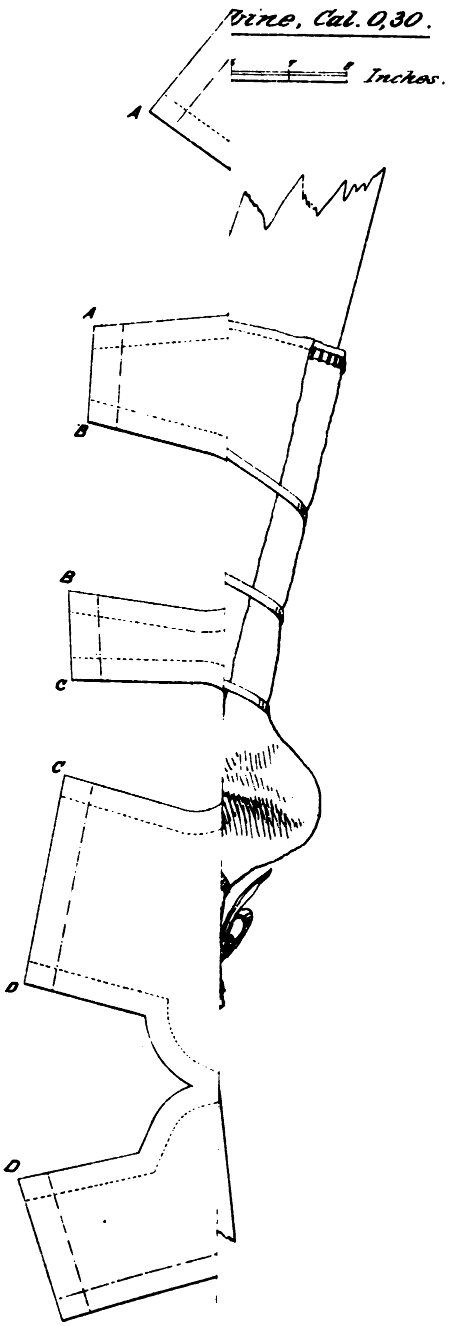
During Indian troubles a few years ago it became necessary, in the effort to turn out promptly some ordnance stores required for immediate issue, to run parts of the shops at night, which was done only under much difficulty on account of inadequate lighting, no provision for night work having been made, and the men being compelled to work under great disadvantages by such lights as lamps or candles might afford. Since that date a partial lighting plant has been established, but it is not sufficient for the general illumination of either the office or the shop where it was introduced. More lights should be provided in the shops and the system extended to some other buildings, and to the main roads and avenues. An estimate for such a plant is submitted.

Respectfully,

S. E. BLUNT,
Captain, Ordnance Department, U. S. A., Commanding.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

(9981—Enc. 2)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APPENDIX 3.

REPORT ON EXTRAORDINARY REPAIRS OF DIKES AND DAMS OF ROCK ISLAND WATER POWER.

(7 plates.)

ROCK ISLAND ARSENAL,
Rock Island, Ill., July 27, 1897.

SIR: I have the honor to submit report as follows, concerning "Extraordinary repairs of the dikes and dams of the Rock Island Water Power," of which work I was placed in charge in June, 1896, by the verbal orders of Col. A. R. Buffington, Ordnance Department, then commanding the arsenal.

At the beginning of the fiscal year 1896–97 the work which remained to be done consisted in the closing of five of the gate openings in the Moline wall, and the erection of a new wall at the west end of the stone dike.

The position and dimensions of this wall are shown in the drawing which was sent by the commanding officer of this arsenal January 23, 1897, to the Chief of Ordnance, United States Army.

In plan the new wall is L-shaped, the two wings being 192 and 208 feet long, respectively, with a heavy triangular pier at the angle.

The wheel openings are 25 in number, 12 in one wing and 13 in the other.

Although the head of water is only about 8 feet, the great variation in the stage of water in the Mississippi River rendered it necessary to put the top of the wall at an elevation of 25 feet above low-water mark.

As the bottom of the wheel pits is 5 feet 6 inches below low-water mark, the total height of the wall is therefore 30 feet 6 inches. It contains approximately 3,500 cubic yards of concrete.

The gate openings are 8 feet square, with the top in the form of a segmental arch having a rise of 8 inches.

The gates are made of cast iron, in five pieces, which work up and down between cast-iron slides bolted to the wall.

The wall is 6 feet 6 inches thick at the base and 3 feet 6 inches thick at the top, with counterforts that extend back 16 feet and form the sides of the penstocks.

The counterforts up to a height of 6 feet are 4 feet thick, and above that 3 feet thick, thus making an offset of 6 inches on each side upon which the flume floors will rest.

This form of wall was adopted as one giving great stability with a minimum number of cubic yards of masonry.

The drawing referred to also shows the position of the new dike which it was necessary to construct in order to connect the old stone dike to the Illinois shore.

The site of the new wall being under water, it was necessary to build cofferdams around it.

The work of placing the cofferdam in the tailrace below the site of the wall, preparations for which had been begun during the previous fiscal year and abandoned on account of high water, was taken up on the 1st of July, when the water had fallen sufficiently to allow the work to proceed.

It was expected at first to provide for the sewage from Moline, which emptied into the tailrace above the proposed new wall, by placing a sewer pipe about 36 inches in diameter under the wall near the end next to the Illinois shore.

In view of apprehended legal difficulties which might arise in case the flow of sewage were not amply provided for, the commanding officer decided to put in a sewer of such a size that no question could ever be raised in the matter.

A concrete sewer 8 feet wide and 8 feet high was decided upon.

The excavation for this sewer was very tedious and expensive, as the site of it had to be inclosed with cofferdams and a steam pump kept running continuously in order to keep it dry enough to do the work.

As the flow of water in the tailrace could not be obstructed, the cofferdam across the tailrace could not be completed until the sewer was finished.

The delay caused on this account was even more costly than the sewer itself, as it was absolutely necessary to carry on the work of removing the old stone dike, due to the short working season remaining after high water was over, even though it was done in very cramped quarters, and consequently to great disadvantage.

The cofferdam in the water-power pool above the new wall was 10 feet thick and 16 feet high; the one in the tailrace was 6 feet thick and 12 feet high.

In pumping out the area inclosed by the coffers a 10-inch centrifugal pump was used, the power being a 20-horsepower electric motor.

It was necessary to keep this pump running continuously during the progress of the work, as the seams in the rock permitted constant leakage under the coffers, and there were, besides, several springs within the area inclosed.

The old stone dike was removed by loading into dump boxes placed on small cars, which were hauled up an incline to the height of the new dike by a portable engine fitted with a hoisting drum.

Four cars were taken out at once (each containing about three-fourths of a cubic yard), the line being attached to the rear end of the fourth car, which pushed the other three up the incline and around a curve in the track, whence they were carried by gravity to the dump and afterwards to the starting point, the track being laid in a continuous circuit.

After the removal of the first 200 feet of the west end of the dike the surface of the rock was blasted off until hard, sound rock was reached; the wheel pits were also blasted out and all the rock removed was carried away in dump boxes on cars, as in case of the stone dike.

The riprap stones from the dike were reserved so far as was necessary for riprap of the new dike, the remainder being crushed for making concrete. The new wall is entirely of concrete.

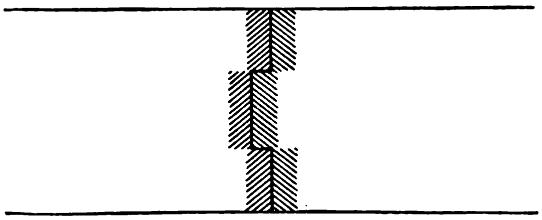
This material was chosen because it is more durable than any stone that could be procured with the means available, and because of its cheapness and of the rapidity with which it can be placed.

In erecting the wall the foundations up to the level with the flume floor were first placed and allowed to harden for several days before the upper wall was begun. A level surface was thus secured upon which to erect the large molds.

These molds were built of timbers 8 by 10 inches by 24 feet, placed vertically and tied together with three-fourths-inch iron rods, which were left in the wall when the molds were taken down, the projecting ends being afterwards cut off. The planking was 2 by 12 inches by 16 feet, dressed to uniform thickness, and lightly nailed to the uprights at the ends.

The molds were 16 feet long, a counterfort being at the middle of each one, and one mold containing about 95 cubic yards was filled each day.

The center of each section being taken at the middle of a counterfort, the vertical joint between adjacent sections came over the middle of the gate openings. These vertical joints were made so that the two sections were locked together, thus:



As each mold was filled from bottom to top in a single day, there are no horizontal joints in the wall, except at the top of the foundations. As a precaution against sliding at this joint, 3-inch planks were embedded in the foundation with their top surface flush with the upper surface of the concrete; when these planks were removed they left a series of depressions in the top of the foundations, into which the concrete of the wall was rammed.

The object of building the wall in this manner—that is, in short sections, with none but vertical joints—was to locate all cracks caused by shrinkage in setting and by contraction from cold at predetermined points, and to secure a number of small cracks instead of a few large ones. This mode of construction was adopted after observation of another water-power dam at Rock Island Arsenal, which is built of sandstone. During very cold weather a number of cracks are developed in this sandstone wall, due to the contraction of the masonry.

In a total length of 650 feet can be counted eight vertical cracks, several of which are more than an eighth of an inch wide, the total contraction being about 1 inch.

These cracks occur at irregular intervals and run in zigzag lines from the top of the wall downward. In some cases they coincide with joints between the stones, but in others they run through the stones, and in one case a large stone 2 feet thick is cracked through the middle from top to bottom.

Had this unavoidable contraction caused the formation of 41 cracks, corresponding to the 41 gate openings, instead of only 8, tney would each have been only one-fortieth of an inch wide.

No setting cracks in the concrete wall were noticed, but as cold weather came on the joints opened very slightly, as was expected.

No facing of sand and cement was used, the only attempt to make the surface smooth being to have the concrete thrown with shovels hard against the sides of the mold.

The materials used in the concrete were Empire Portland cement, sharp, clean river sand, and crushed limestone, unscreened.

The stone used for crushing had been exposed to the weather for years, was well seasoned, and very hard. Freshly quarried stone was used a little, but it was found that much less of it could be crowded through the crusher in a day.

About 50 per cent of this crushed stone would pass through a 1-inch sieve, about 17 per cent would pass a No. 3 sieve, and about 9 per cent would pass a No. 8 sieve.

These materials were mixed in the following proportions: One barrel of cement, 4 barrels of sand, and 9 barrels of broken stone, each barrel of cement giving almost exactly a cubic yard of concrete when tamped to place.

The concrete was mixed in a Cockburn-Barrow mixer with screw feed, and carried in dump boxes on cars to the point where it was to be placed. It was then elevated to the top of the mold by means of a crane derrick and a steam engine.

The dump boxes used were made of a 2-inch pine planking, and were 2 feet wide, 5 feet 4 inches long, and 14 inches deep.

They were usually loaded with about one-fourth of a cubic yard of concrete.

The derrick was on wheels and was moved along a track as the work progressed.

As the concrete was dumped into the molds it was spread by a gang of men working with shovels, who were required to throw the concrete hard against the sides of the molds, the shovelers being followed by a gang of men who rammed it to place. The rammers used were made of cast iron with wrought-iron handles, and weighed about 30 pounds each.

The concrete, which was mixed as wet as it could be made without causing the mass to quake when tamped, was placed in thin layers (not over 6 inches), and the ramming was very thorough.

Less cement was used in this wall than is ordinarily the case in important works.

Two reasons for this may be given:

First. The strength of the cement used was very high, and the terms of the contract were such that it is believed very little inferior cement could have been passed, even had the contractors been inclined to attempt such a thing.

Second. All vork was done by day labor, directly under the supervision of the officer in charge of the work, and there was no temptation to do inferior work.

The specifications for cement were as follows:

"Four thousand barrels (more or less) of best quality Portland cement. The cement required shall be well seasoned and must possess the following qualities: Fineness, 95 per cent to pass through a sieve 50 by 50, equal to 2,500 meshes per square inch. Weight, struck weight of a bushel to be from 104 to 108 pounds, through a fall of 30 to 36 inches. Tensile strength, neat (no sand), one day in air, six days in water, 450 pounds per square inch; tensile strength, 1 cement and 3 sand, for same time as above, 140 pounds per square inch. Initial set to be over thirty minutes and the final set not over twelve hours. A thin pat of neat cement molded on glass, when immersed in water at 212° for twenty-four hours, shall not show signs of cracking or warping. Parties desiring to bid will send as soon as possible to the undersigned samples weighing not less than 25 pounds net for test, free of charge. Parties will state brand of cement, whether imported or domestic, and net weight per barrel. Deliveries are to be made as follows: Five hundred barrels immediately upon notification of acceptance of bid, the remainder in such quantities and at such times as the undersigned may require. The United States reserves the right to test every barrel, and will test 10 per cent of the barrels of each carload lot, and if the tests be unsatisfactory the carload lot will be rejected, and the contractor will be required to remove the same at once. The quantity is only approximate, and the United States reserves the right to increase or decrease it to such an extent as may be found necessary.

The price given in the bid must include delivery at this arsenal.

The successful bidder will be required to enter into a formal written contract, with good and sufficient bond, for the faithful performance of same.

Although all the acceptance tests of all the cement received were entirely satisfactory, another series of tests were carried on during the progress of the work which was considered of more value and importance.

These tests were as follows:

Briquets for both tension and compression were made in the field out of the mortar for the concrete. The concrete was taken just as it came from the mixer, the stone picked out by hand, and the mortar used for the briquets.

The briquets for tensile tests were of the standard dimensions, those for crushing were 2 by 2 by 4 inches and were intended to be crushed on end.

Most of them were so crushed, but in order to see how much stronger they were on the side a few were crushed in that position. Strange to say, but comparatively little difference in the strength was noted, as may be seen from subjoined tables.

The average crushing strength per square inch at the end of thirty days when broken on end was 1,242 pounds, and when broken on the side was 1,671 pounds.

At the end of ninety days the average crushing strength per square inch was 1,469 pounds when broken on the end, and 1,937 pounds when broken on the side.

At the end of one hundred and twenty days the average crushing strength per square inch was 1,675 pounds when broken on end, and 2,249 pounds when broken on the side.

In addition to these small briquets from the mortar there were also a number of concrete blocks made for crushing.

The clamps at present on the testing machine are adapted to crushing specimens whose horizontal dimensions are less than 4 by 6 inches. As an alteration in these clamps would have involved considerable expense, all the concrete blocks were made 3¾ inches wide and 5¾ inches long and 8 inches high.

A few blocks 3¾ by 5¾ by 27 inches were also made for breaking by transverse stress.

When it was noticed how little difference there was in the crushing strength per square inch of the small specimens when broken on end and when broken on side, it was decided to extend this test to the larger specimens. Three of these long blocks were sawed in two, making from each two blocks for crushing 8 inches and 19 inches high respectively.

The crushing of these gave results even more remarkable than those obtained in the case of the small ones.

The crushing strength per square inch of the three blocks 8 inches high was 1,486, 1,396, and 1,309 pounds respectively, while the corresponding pieces which were 19 inches high gave 1,391, 1,577, and 1,345 pounds respectively, which was higher on an average than in the case of the three 8-inch blocks.

Particular importance is attached to these field tests, as it is thought that they show more nearly what was the actual strength of the material as it went into the wall than could any laboratory tests, however carefully made, and the results obtained indicate very clearly the value good concrete would have for use in columns or high thin walls.

The results obtained in these tests are given below in tabulated form.

The work of placing the first concrete for the foundation of the wall could not be begun until October 20, and yet, in spite of a number of

days being lost on account of the weather, the last section of the wall was completed on December 9, 1896.

Since that date no work looking toward the completion of the removal of the remainder of the old stone dike has been done.

Very respectfully, your obedient servant,

ODUS C. HORNEY,
Lieutenant, Ordnance Department, U. S. A.

The COMMANDING OFFICER, ROCK ISLAND ARSENAL, ILL.

TABLE OF TESTS.

Tensile tests of mortar used in the construction of water-power dam at Rock Island Arsenal, Ill.

[Concrete from which this mortar was taken was composed of 1 part Empire Portland cement, 4 parts sand, and 9 parts crushed limestone.]

No. of specimen.	Dimensions.	Area to which stress was applied.	Duration of test.	Breaking stress per square inch.	Remarks.
1	Standard tensile briquets.	....	7 days....	160	Made from mortar from machine-mixed concrete November 16. Weather dry and moderate. Briquets remained in open air 48 hours and then placed in water.
2	.....do	....	.... do	164	
3	.....do	....	.... do	120	
4	.....do	....	.....do	150	
5	.....do	....	.....do	145	
1	.....do	....	.....do	146	Made from mortar from machine-mixed concrete December 9. Weather freezing. Briquets were removed to a warm room to set, remained there 24 hours, then removed to testing-room and placed in water.
2	.....do	....	.....do	145	
3	.....do	....	.....do	152	
4	.....do	....	.....do	149	
5	.....do	....	.....do	144	
1	.....do	....	30 days...	157	Made from mortar from machine-mixed concrete November 24. Weather warm and damp. Briquets left outside. The 26th it rained all day and in the evening changed to freezing. Briquets remained in the freezing weather until the 28th. Immersed in water the 30th.
2	.....do	....	.....do	157	
3	.....do	....	.....do	200	
4	.....do	....	.....do	162	
5	.....do	....	.....do	196	
1	.....do	....	60 days...	207	Made from mortar from machine-mixed concrete December 9. Weather freezing. Briquets were removed to a warm room to set, remained there 24 hours, then removed to testing room and immersed in water.
2	.....do	....	.....do	206	
3	.....do	....	.....do	250	
4	.....do	....	.....do	222	
5	.....do	....	.....do	209	
6	.....do	....	.....do	220	
7	.....do	....	.....do	203	
8	.....do	....	.....do	209	
9	.....do	....	.....do	204	
1	.....do	....	120 days..	337	Made from mortar from machine-mixed concrete November 16. Weather dry and moderate. Briquets remained in open air 48 hours and then placed in water.
2	.....do	....	.....do	357	
3	.....do	....	.....do	378	
4	.....do	....	.....do	370	
5	.....do	....	.....do	280	
1	.....do	....	.....do	290	Made from mortar from machine-mixed concrete November 24. Weather warm and damp. Briquets left outside. The 26th it rained all day and in the evening changed to freezing. Briquets remained in the freezing weather until the 28th. Immersed in water the 30th.
2	.....do	....	.....do	294	
3	.....do	....	.....do	294	
4	.....do	....	.....do	293	
5	.....do	....	.....do	298	

Crushing tests of mortar from concrete used in the construction of water-power dam, Rock Island Arsenal, Ill.

[The concrete from which this mortar was taken was composed of 1 part Empire Portland cement, 4 parts sand, and 9 parts crushed limestone.]

No. of specimen.	Dimensions.	Area to which stress was applied.	Duration of test.	Breaking stress. Total.	Breaking stress. Per square inch.	Remarks.
1	2 by 2 by 4 inches.	2 by 2 inches	30 days	3,785	946¼	Made from mortar taken from machine-mixed concrete November 25. Weather damp and moderate. Specimens were left in open air. On the 26th it rained all day and the weather changed to freezing in the evening. Specimen remained out in freezing weather until the 28th and then removed to testing room. Immersed in water on 30th.
2	do	do	do	3,570	892½	
3	do	do	do	3,850	962½	
4	do	do	do	4,425	1,106¼	
5	do	do	do	4,830	1,207½	
1	do	2 by 4 inches	do	9,375	1,171⅞	Made from mortar taken from machine-mixed concrete December 7. Weather freezing. Warm water used in mixing concrete. Specimens removed to warm room to set. Taken from molds on the 8th, immersed in water on 9th.
2	do	do	do	11,550	1,443¾	
3	do	do	do	11,200	1,400	
4	do	2 by 2 inches	do	5,050	1,262½	
5	do	do	do	4,900	1,222	
1	do	do	90 days	4,900	1,222	Made from mortar taken from machine-mixed concrete December 8. Weather freezing. Specimens were placed in warm room to set. They were removed from molds December 9 and on 10th immersed in water.
2	do	do	do	7,650	1,912½	
3	do	do	do	5,100	1,275	
4	do	2 by 4 inches	do	15,200	1,900	
5	do	do	do	15,800	1,975	
1	do	2 by 2 inches	120 days	5,850	1,462½	Made from mortar taken from machine-mixed concrete November 16. Weather dry and moderate. Specimens remained in open air 48 hours and then placed in water.
2	do	do	do	7,100	1,775	
3	do	do	do	7,150	1,787½	
4	do	2 by 4 inches	do	18,200	2,273¾	
5	do	do	do	17,800	2,225	

Crushing tests of concrete used in construction of water-power dam at Rock Island Arsenal, Ill.

[Concrete composed of 1 part Empire Portland cement, 4 parts sand, and 9 parts crushed limestone.]

No. of specimen.	Dimensions.	Area to which stress was applied.	Duration of test.	Breaking stress. Total.	Breaking stress. Per square inch.	Remarks.
1	3¾ by 5¾ by 8 inches	3¾ by 5¾ inches	30 days...	30,735	1,407	Made from machine-mixed concrete November 24. Weather warm and damp. Specimens left in open air to set. On the 26th it rained all day and in the evening weather changed to freezing. Specimens remained in freezing weather until 28th, when they were removed to testing room. Not immersed in water.
2	.....do	.....do	.....do	24,890	1,154	
3	.....do	.....do	.....do	25,200	1,169	
4	.....do	.....do	.....do	25,660	1,185	
5	.....do	.....do	.....do	24,050	1,115	
6	.....do	.....do	.....do	21,605	1,002	
1	.....do	.....do	.....do	24,870	1,153	Made from hand-mixed concrete December 12. Weather moderate. Specimens left in open air until 14th, when they were removed to testing room. Not immersed in water.
2	.....do	.....do	.....do	23,500	1,089	
3	.....do	.....do	.....do	31,450	1,435	
4	.....do	.....do	.....do	24,450	1,134	
5	.....do	.....do	.....do	23,350	1,083	
1	.....do	.....do	60 days...	26,300	1,219	Made from machine-mixed concrete November 13. Weather warm. Specimens left in open air until they were set. They were removed to testing room November 15 and immersed in water, remaining there until crushed.
2	.....do	.....do	.....do	27,400	1,270	
3	.....do	.....do	.....do	23,050	1,068	
4	.....do	.....do	.....do	28,650	1,328	
5	.....do	.....do	.....do	25,750	1,194	
1	.....do	.....do	90 days...	25,800	1,197	Made from machine-mixed concrete December 7. Weather freezing. Warm water used in mixing concrete. After specimens were made they were removed to warm room to set. Not immersed in water.
2	.....do	.....do	.....do	27,000	1,252	
3	.....do	.....do	.....do	26,300	1,219	
4	.....do	.....do	.....do	25,700	1,192	
1	.....do	.....do	120 days..	32,050	1,486	Made from machine-mixed concrete. Weather dry and moderate. Left out of doors 48 hours and then removed to testing room. Not immersed in water.
2	.....do	.....do	.....do	30,100	1,396	
3	.....do	.....do	.....do	28,200	1,309	
1	(a) 3¾ by 5¾ by 19 inches.	.....do	.....do	30,000	1,391	
2	.....do	.....do	.....do	34,000	1,577	
3	.....do	.....do	.....do	29,100	1,345	

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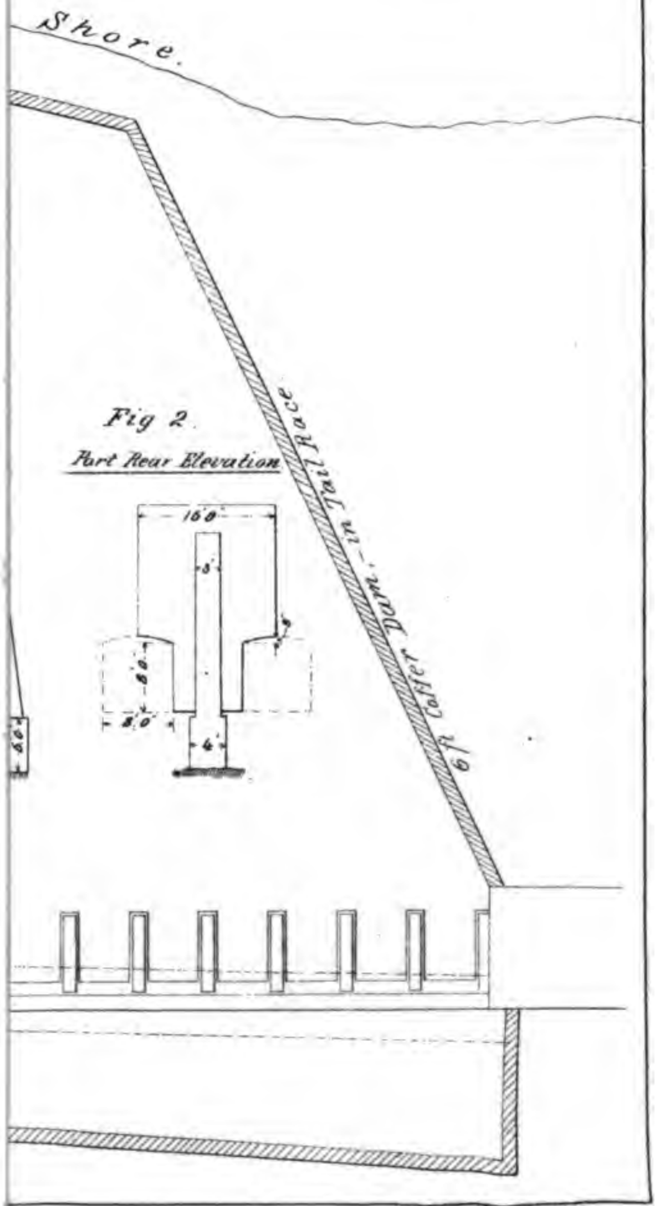
...er Power Dam Wall.

10 0 10 20 30 40 50 Feet.

Fig.s 1 & 2 10 0 10 20 Feet.



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APPENDIX 4.

REPORT ON THE MANUFACTURE OF SADDLETREES.

(3 plates.)

ROCK ISLAND ARSENAL,
Rock Island, Ill., July 31, 1897.

SIR: I have the honor to submit report as follows concerning the manufacture of saddletrees at this arsenal, of which work I was placed in charge in March, 1896, by the oral orders of Col. A. R. Buffington, Ordnance Department, then commanding the arsenal.

In the manufacture of saddles at this arsenal old saddletrees have been used exclusively, until recently. The old trees that have been used were handmade, and varied considerably in size and shape, and it became necessary to prepare maximum and minimum gauges for each size of tree, in order to determine which should be used and which condemned.

In March, 1896, I made an examination of the old saddletrees then on hand, with a view of determining how long the supply would last.

As it was evident that the manufacture of new trees would have to be taken in hand at an early date, a careful inspection of old condemned trees was made, to determine, if possible, what were the weakest points in their construction, so that in the new trees these defects might be remedied.

It was found that a great number of old trees were broken through the pommel, while others were rendered unfit for use by excessive warping of the side bars.

These were almost the only causes for the rejection of saddletrees.

To remedy these defects I devised a form of pommel arc and cantle arc which, it is believed, entirely overcomes the difficulties mentioned.

On March 30, 1896, pursuant to oral instructions from the commanding officer, I made a written report of the matter and submitted a model saddletree fitted with these new arcs.

In preparing this tree, the hasps or straps with which the stirrup loops were secured to the side bars were made with half-round ends instead of square ends as heretofore. This was done so that the mortise into which these hasps fit can be cut out on a molding machine.

The shape of the tree is that approved and recommended by the cavalry equipment board of 1874, as modified by the cavalry equipment board of 1884.

It follows the drawings made at this arsenal April 26, 1886.

This model was approved by the Chief of Ordnance April 4, 1896, and the commanding officer of this arsenal was directed to prepare fifty saddles of the new model for trial in service.

The turning of the side bars, due to their very irregular shape, requires a very strong, rigid machine, and as it was found that such a machine as

was needed would be very expensive to buy, a form of eccentric lathe adapted to this work was devised and manufactured at this arsenal.

On account of the press of work in the machine shop considerable time elapsed before this machine was completed.

The fifty saddles for trial were completed on February 18, 1897, and are now in use.

The tree consists of 2 side bars, 1 pommel, 1 cantle, 1 pommel arc, 1 cantle arc, 2 stirrup loops, 2 stirrup-loop hasps, 18 rivets, and 8 screws.

It was necessary to do some experimenting to determine the best methods for manufacturing these trees. The following is the method finally worked out:

The side bars are made of basswood, on account of its lightness and the difficulty with which it splits. They are first roughly sawed to shape, as shown in fig. 1, Pl. I, and then turned out on the eccentric turning lathe above referred to, which turns two pieces at once. The side bar as it comes from the lathe is shown in figs. 2 and 3, Pl. I.

After being turned the side bars are fitted to cast-iron forms and smoothed on a sandpapering machine. The mortises for the stirrup-loop hasps are then cut on a molding machine, the side bars being held in a jig to secure uniformity in the position of these mortises. The finished side bar is shown in fig. 4, Pl. I.

The pommel is made of ash in two pieces, fitted and glued together with a tongue and groove joint, as shown in figs. 10 and 11, Pl. I. The tongue is made with the grain running at right angles to the line of the joint. The pommel is first sawed roughly to shape on a band saw, as shown by dotted line, fig. 10, and then brought to proper dimensions on molding or shaping machine.

The faces which come in contact with the side bars are brought to the proper bevel on a disk sandpapering machine.

The mortise is first bored and then cut out under a boring and mortising machine, the pommel being clamped to a jig, so that all are cut exactly alike. The finished pommel is shown in figs. 12 and 13, Pl. I.

The cantle is made of ash in two pieces, which are fitted together as in the case of the pommel. After being sawed roughly to shape on a band saw it is turned to its finished dimensions on a lathe.

The surfaces which come in contact with the side bars are brought to proper bevel on a disk sandpapering machine, and the mortises are cut out as described for the pommel. Figs. 5 to 9, Pl. I, illustrate the process of manufacture of the cantle, figs. 8 and 9 showing its finished form.

The pommel and cantle are each secured to the side bars with No. 12 iron screws, two 1½ inches long and two 1¾ inches long.

In the old saddles this was the only connection between pommel and cantle and side bars, but in those now manufactured they are further connected through the new form of pommel and cantle arcs above referred to.

The pommel arcs are made by first punching out the blanks from soft sheet steel of No. 16 gauge (Stubbs). The blanks are heated and pressed to shape between dies on a bulldozer, and the edges are then ground off to a bevel, so that when the tree is covered there will be no sharp edge to cut the rawhide.

The pommel arc is shaped to the angle between the side bars and the front of the pommel, and is secured to the plane surfaces of the side bars and to the front face of the pommel by No. 8 iron rivets—two in pommel and two in each side bar.

The cantle arcs are made of the same material and in the same way as the pommel arcs. They are shaped to fit the curved surface of the back of the cantle and the plane surfaces of the side bars in rear of cantle.

The method of fastening is exactly the same as in case of pommel arc. The forms of the pommel and cantle arcs are shown on Pl. II, figs. 1 and 2, and their position on the saddletree is shown in fig. 3, same plate.

The stirrup loops are secured to the side bars by means of straps, which are riveted by three No. 8 rivets, arranged in zigzag order, so that no two shall be in line with the grain of the wood. The straps are of low steel No. 18 (Stubbs's gauge).

The different parts of the saddletree are assembled on cast-iron forms, so that they are very uniform in size and shape.

The tree, after being painted with white lead, is covered and trimmed in the same manner as were the old trees heretofore used.

The following is a bill of material for one saddletree: Two pieces basswood $2\frac{1}{2}$ by 7 by 26 inches; 2 pieces ash $1\frac{1}{2}$ by 3 by $8\frac{1}{2}$ inches; 2 pieces ash $1\frac{1}{2}$ by 5 by $8\frac{1}{2}$ inches; 1 piece $2\frac{1}{2}$ by $14\frac{1}{2}$ by 0.065 inch, 1 piece $2\frac{1}{2}$ by $12\frac{1}{4}$ by 0.065 inch, 1 piece $1\frac{5}{16}$ by $9\frac{3}{4}$ by 0.049 inch best quality low decarbonized sheet steel; 1 piece best wrought-iron wire (annealed) 0.284 inch diameter by $10\frac{1}{2}$ inches long.

NOTE.—In ordering lumber about 6 per cent of wastage should be allowed for.

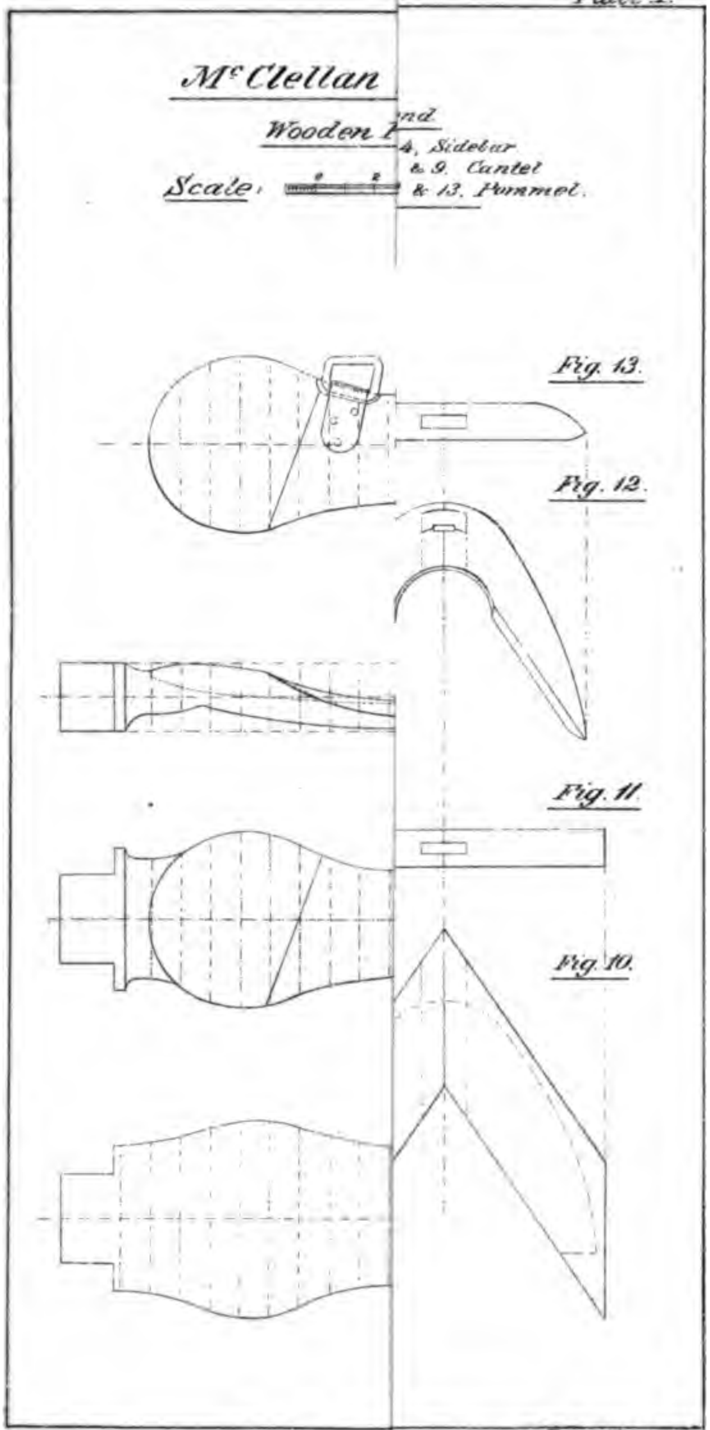
Very respectfully, your obedient servant,

ODUS C. HORNEY,
Lieutenant, Ordnance Department, U. S. A.

The COMMANDING OFFICER, ROCK ISLAND ARSENAL, ILL.

(9981—Enc. 3)
ORD 97——5

Plate I.



Appendix 4, 1897

Ord 55 2

APPENDIX 5.

REPORT ON FOUNDATIONS OF SHOP G, ROCK ISLAND ARSENAL.

[By Lieut. Col. D. W. Flagler, commanding, for year ended June 30, 1878.]

(1 plate.)

SHOP G.

IRON WORKING AND FINISHING SHOP FOR THE ARSENAL.

The foundations of this building were completed during the fall of 1877, the footing stones put on, the front area walls built, sewers and water pipes put in, the stone for the basement story purchased and cut, and the iron beams for one-half of the first floor purchased and fitted ready for putting in position.

A full description of the difficulties encountered in getting foundations for a portion of this building, with drawings and descriptions of the foundation walls and strata passed through, were sent to you with my last annual report (1877).

The portion of the foundations put in during this fiscal year are shown on drawing A, transmitted herewith and included between G and M in the plat of the building. (See fig. 1 on drawing A, transmitted herewith.) The strata passed through are shown in fig. 2. This drawing, in connection with drawings D and E (No. 549 a and b, R. I. A.), sent with my last annual report, give a complete description of the foundation of this shop.

In prosecuting the work on the foundations during the present fiscal year (in the fall of 1877) great difficulty was found in procuring satisfactory foundations from x to q on fig. 1. The depth of excavation at this point was 54 feet. The general character of the strata passed through was soft, yielding clay with loose rock, sometimes in large masses, bedded in it. Some of the pieces were estimated to contain over 30 cubic yards, weighing about 67 tons, and as the excavation passed below them they settled very slowly, crowding against the sheathing with such force as to crush the heaviest timber I could put in. It was necessary to remove these, and in doing this and in excavating for and testing rock for footing for arches to build on the excavations extended in two places 16 feet laterally from the lines of the building. Below the level of the river the flow of water into the excavation indicated that it came through seams in the rock from the bed of the river. Two steam pumps with 325 gallons per minute capacity were employed night and day in pumping, and the workmen had generally to carry on the excavation in water from 1 to 2 feet deep, which interfered seriously with progress. The material was hoisted out in buckets with steam power.

After reaching a depth of 27 feet I made careful soundings and borings to determine whether piling could be resorted to, but the above description of the strata found shows that this was not feasible.

PLATE III.

Appendix 4, 1897.

APPENDIX 6.

REPORT OF PRINCIPAL OPERATIONS AT SPRINGFIELD ARMORY DURING THE FISCAL YEAR ENDED JUNE 30, 1897.

SPRINGFIELD ARMORY, MASS., *August 27, 1897.*

SIR: I have the honor to submit the following report of the principal operations at this armory during the year ending June 30, 1897:

BUILDINGS AND GROUNDS.

The second new set of quarters for officers remains in the same unfinished state as at last report, no funds having been furnished for its completion.

In the main arsenal an hydraulic elevator has been erected capable of carrying a load of 1,200 pounds to the third floor. This has added greatly to the value of the building as a storehouse.

All the shops and quarters and other buildings have received from time to time such repairs as were needed, and they all, with the exception of the want of new paint on the exterior of some, are in very good order. All the quarters, the barracks, and the hospital have in the last few years had the plumbing repaired and altered, and all now have a modern system.

The fence about the square which contains the new shops has been repaired and painted with two coats; the same has been done to the fence about the grounds at the water shops.

The city has recently graded and macadamized the portion of Allen street, the property of the United States, lying along the land about the water shops, and the tracks of the Springfield street railway are now to be extended over Allen and Mill streets, the Secretary of War having granted a "revocable license" for that purpose.

MAGAZINE RIFLE AND CARBINE.

All the arms fabricated during the year have been of model 1896, the distinguishing features of which have been already described. A slight modification has been made in the shape of one of the holes in the butt of the stock, whereby a small oiler of brass, nickeled, can be carried in each arm with the sectional cleaning rod.

The arms in the hands of troops having been provided with rear sights, model 1896, the manufacture of an extra number has been continued, and all the arms in store with the model 1892 sight have been supplied with new sights, except about 3,000, on which the change will be made within a few months.

The change in the operation of the cut-off, heretofore proposed, and which at date of the last annual report had not been found to work satisfactorily, has now been accomplished and can be carried into effect whenever ordered.

By this alteration, the thumb piece of the cut-off will be turned down when the magazine is "off" and up when the magazine is "on." It is also contemplated to shorten the spindle body of the cut-off, that there may be less liability of the bolt jamming a cartridge under certain movements.

The determination of the deviation of the rifle and carbine has met with much difficulty and many delays, on account of the almost impossibility of obtaining on any range a total absence of wind.

Firings have been had at the ranges over the water shops pond, at Sandy Hook Proving Ground, and at a range obtained on private property, situated about 6 miles from the armory, the owners of which have kindly loaned their land.

For three months during this summer a party of employees, good marksmen, have been camped at this range and have taken advantage of every suitable moment between daylight and dark to make the targets desired, and still, with all the time and labor expended, all of those required have not been obtained. A complete report of what has been accomplished will be submitted later.

Firings to determine the effect of the wind on the .30-caliber bullet have been conducted and completed; the results will be reported within a short time.

MANUFACTURE OF ARMS.

The machines, fixtures, and tools used in manufacture have worked during the year with entire satisfaction, and the arms turned out are, it is believed, the best made and the most accurately constructed ever produced at this armory.

Continued attention to the barrel-drilling machines has resulted in obtaining in a given time better and more work than, it is understood, has yet been accomplished by any private factory.

One man now operates ten spindles, and in a day drills 60 rifle or 75 carbine barrels, and these are so true that the labor and skill required to straighten them thereafter has been greatly diminished.

The barrels are rolled from a bar 1.15 inches instead of 1.4 inches in diameter, as heretofore, and six grooves in the place of eleven are used in the rolls; the forms are brought much nearer to the finished shape, and thus the amount of turning is diminished and a more accurate surface obtained. Less metal remains to be removed in polishing. The operation of "second polishing" has been abolished, and it is hoped some simplification can be made in the "first polishing." This change has nearly doubled the daily work of one man.

Younger labor on the turning operate ten lathes per man and turn out with lathes 220 carbines per day, first and second turned. Both the drilling and turning are now paid for by the piece.

The reaming and straightening of the barrels, which were formerly worked together, have been separated and a piece price put upon each. This has rendered it practicable to use a different grade of workmen and has resulted in benefit to the shop.

In the rifling, two men operate 18 machines, turning out daily 160 barrels for carbines and a proportional number for rifles.

As the plant for forging receivers has a capacity of only 160 per day, two additional coal furnaces have been built during the year, which, with one 1,800-pound drop hammer to be put in, will double the "output" of receiver forgings.

A double exhaust fan, 40 inches in diameter, has been provided to carry off the gases and smoke from the receiver forges and to ventilate the space about them for the comfort of the workmen.

A 34-inch exhaust fan has been placed in the polishing room at the water shops, which adds much to the ventilation and comfort.

A new pickling house, of brick, has been built, to replace the frame building, which had become irreparable, rotten, and eaten by the acid.

The generator for the gasoline gas for forging having become unserviceable, and a new one having been judged necessary, consideration was given to the change of a number of the forges from gasoline to coal.

When gasoline gas was introduced for lighting the water shops, the price of coal gas was high and that of gasoline low. This has become reversed, and as the light from the latter was very inferior its use was discontinued, and in November last connection was made for the city gas, which has since been used.

The plant for the illuminating gasoline gas is now being employed and furnishes all the gas required for forging, the amount necessary having been much reduced by the forges, which have been altered to burn coal. This gives excellent forgings and the promise that they will be obtained at a reduced cost.

The extension of "face milling," referred to in report of last year, has been accomplished, with very satisfactory results.

One of the Pratt & Whitney Company's machines has taken the place of nine plain milling machines. The work is excellent and the amount per day increased, as shown by the operations on the following parts, worked on the one machine:

	Plain milling.	Face milling.
Ejector, right side, per day	240	2,000
Ejector, left side, per day	240	1,400
Rear-sight slide, bottom, per day	450	2,000
Rear-sight slide cap, bottom, per day	450	1,500
Rear-sight slide cap, top, per day	450	1,200
Sear, right side, per day	135	1,100
Sear, left side, per day	135	800
Trigger, right side, per day	a 350	900
Trigger, left side, per day	a 265	600

a Old method.

The same single cutter, in one piece, is employed for the ejector, slide, and cap. The sear being of two thicknesses, has a double cutter of two concentric cylinders, and the trigger being of three thicknesses, has a triple cutter of three concentric cylinders.

The differences in the number of pieces per day for the two sides of a component are due to the time required to gauge the second cut on each.

The three plain milling cuts on the edges of the trigger have been reduced to two, and these combined on one machine, thereby dispensing with two machines; a similar combination has been made on the sear, and one machine now makes the necessary cuts.

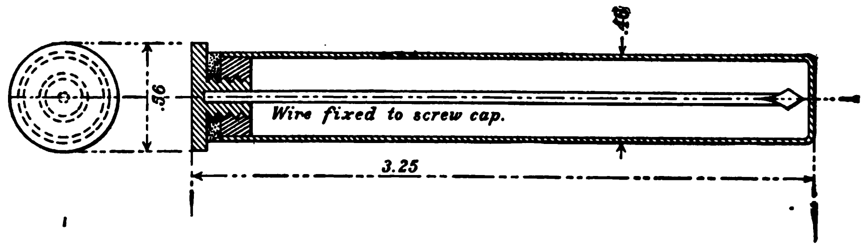
Some operations on the sleeve and on the cocking piece have been transferred to screw machines, and thus is produced better and cheaper work.

The handle of the bolt, formerly turned on a lathe, is now clamp-milled, giving a surface equally as good and at less cost.

It having been decided to supply an oiler, to contain cosmoline oil, for use with the magazine arms, a pattern has been adopted which can

be carried either in the butt of the stock or in a loop of the cartridge belt. As the arms in service have not the stock cut for this purpose, the oilers have been issued to each noncommissioned officer with troops, to be carried in the belt.

The oiler is now placed in each arm fabricated; a drawing showing its construction is herewith.



During about two and a half months of the year the quality of steel for barrels required was not furnished by the contractor, and this caused a deficiency in barrels, whilst the work on the other components progressed regularly; the assembling of guns had to be suspended. When the barrels were forthcoming in May last the deficiency was commenced to be made up by assembling 200 arms per day. This is still carried on, and will be till the accumulated parts have been exhausted, when a return will be made to the "output" of 120 per day.

GATLING GUNS AND REVOLVERS.

The 18 Gatling guns, caliber .30, model 1893, with tin feed strips, which were ordered to be converted at this armory to model 1895, with Bruce feed guide, have been completed.

Seventy-six Gatling guns, caliber .45, of various models, have been sent here for conversion, all to be adapted to use the Bruce feed. Work upon these alterations has been commenced.

A contract with the Gatling Gun Company for 31 guns, caliber .30, model 1895, made by the Bureau March 8, 1897, is in course of execution, the guns being made at the factory of the Colt's Patent Fire-Arms Manufacturing Company, Hartford, Conn.; the inspection is to be done from this armory.

The 8,000 Colt's double-action revolvers, caliber .38, model 1892, procured and issued to the service have all been withdrawn for alteration to model 1894, and have been replaced by either new or altered revolvers of the new model.

As it was estimated that this work of alteration and refitting could be done at this armory at a price much below that offered by the manufacturers, authority was given by you for the work to be done here.

Up to the end of the year 4,000 were altered and made as good as new, and the estimated cost not exceeded.

The parts of new pattern required, viz, hands and springs, locking levers, and locking-lever screws, have been purchased of the Colt's Company, and the work of fitting them to the revolver, cleaning, bluing, browning, and repairing the worn parts, and replacing those unsuitable for use is done at the armory.

CONSTRUCTION OF BARRELS.

During the year continued attention has been given to the metal for rifle barrels and the best methods of treating it to obtain the most satisfactory results.

It has been found entirely possible to obtain a simple carbon steel possessing an elastic limit of 75,000 pounds with suitable elongation and contraction, but the high physical properties do not indicate that the metal is not too brittle for a good barrel.

Much information has been reached by breaking barrels at different stages under a drop hammer, the blow used being always the same. This resulted in resort being had to different methods of annealing the barrels to produce greater toughness. After rolling, in order to machine the metal with success the forms must be annealed in charcoal. To restore the properties thus lost, experiments were made, first, to reheat the annealed forms in the barrel furnace and allow them to anneal (cool) in the air, protected from a draft; second, to heat 9 inches at the butt of the finished barrel in a coal furnace and allow it to anneal (cool) in the air; third, to heat 9 inches at the butt of the finished barrel in a gasoline fire, then remove it and cool by running oil through the interior.

Each one of these treatments produced an increase in the toughness, modifying the brittleness existing. The effect upon the physical properties of the steels treated is shown by the tables herewith.

The temperature of the furnaces used, determined by a Siemens water and ball pyrometer, was 1,350° for some steels and 1,600° for others, it having been found that the same heat for all steel did not produce the same result.

The manufacturers, to produce a stronger and sounder metal, had, besides altering the treatment, increased the proportion of manganese. This increased the hardness and brittleness of the metal by developing the full hardening power of the carbon, and caused the demand that the barrels should be annealed by reheating and cooling in air at some stage of fabrication.

The result was still not all that was desired. Difficulties arose at different operations of machining, and to eliminate the barrels that might contain lines of weakness or other defects the charge for proving was increased to give a pressure of about 75,000 pounds, and thus weak metal ruptured at the proof stage and only reliable barrels, believed to be, allowed to pass.

It was considered that the addition of manganese was one source of injury, and after this view had been confirmed, by consultation with Mr. Howard, of Watertown Arsenal, a standard for analysis was fixed.

The Bethlehem Iron Company undertook to overcome the greatest defect found in the barrel steel, seams and lines of weakness due to primary and secondary "pipe," and after continued urging from this office made some very careful heats and produced the metals, test numbers 103 to 115, Table I.

These, though improvements upon much of the metal previously furnished, still contained lines of weakness, and metal of bad quality arising, principally from the use of too much of the upper end of the ingot, finally it was agreed that at least 50 per cent of the ingot should be rejected, 5 per cent from the bottom and not less than 45 per cent from the top. The result was metal 75–8, S. Table I, test 120.

This steel gave very satisfactory physical properties and fracture, and when heated and cooled with oil produced a barrel superior to any obtained previously from a simple carbon steel by the Bessemer or open-hearth process.

Based upon these results and experiments, the following specifications were prepared and issued in advertisement for barrel steel, and a

bid of the Spaulding & Jennings Company for Bessemer steel to fill these requirements has been accepted and is being carried out, viz:

SPECIFICATIONS.

Two hundred thousand pounds, more or less, of steel for barrels of rifles and carbines; in bars 1.15 inches in diameter. To be a simple carbon steel, made by the Bessemer, open-hearth, or crucible process; to have elastic limit from 70,000 to 75,000 pounds, and higher, if practicable; ultimate tenacity from 100,000 to 120,000 pounds; elongation from 15 to 20 per cent, and contraction from 35 to 45 per cent; must be homogeneous in structure, free from seams, lines of weakness, and all foreign matter, and must be capable of being worked with accuracy in drilling and turning with the tools now used at this armory for the purpose.

The metal must be such that it will not stretch excessively, in proof under 70,000 pounds pressure, or in continuous firing in the gun with service ammunition of not over 40,000 pounds pressure.

The analysis of the steel shall give: Carbon, about 0.50; manganese, 0.80 to 1; silicon, 0.10 to 0.18; sulphur, not above 0.08; phosphorus, not above 0.06; nickel, none.

The physical properties and analysis admitted shall be those determined by the Ordnance Department.

The billets, however made, before being heated for rolling, must be carefully inspected, and all that show evidences of seams or other defects must be rejected.

The stock used must be thoroughly "welded" and allowed to cool, and then inspected for seams.

The bars must be rolled at a uniform temperature to exact size, and, when finished, trimmed by hand with chisel and sledge, and if any appearance be found of defects from piping or other cause, such bars shall be rejected.

The following specifications for steel by the Bessemer process shall be observed for open-hearth and crucible steels wherever it may be possible to apply them, especially that for the portion of each ingot to be discarded, viz:

1. This steel to be made from special iron of high grade, carefully selected.
2. Particular care must be given to the melting and blowing, and the metal must be thoroughly agitated in the ladle after recarburization to insure the uniform admixture of recarburizer, and then held at least five minutes before teeming into the molds.
3. The molds must be carefully prepared, and be free from patching and other defects. The teeming of the metal into the molds must be done with care, to provide against the splashing or scattering of the metal.
4. The ingots must show no tendency to rising at the top, and when sufficiently solidified, must be carefully heated and rolled.
5. At least 5 per cent from the bottom and 45 per cent from the top of the ingot will be discarded.
6. The blooms must be cut by means of a hammer, and not sheared, and all blooms showing any indications of pipe will be rejected. If any surface cracks or defects develop during rolling, so much of the bloom as show these defects must be cut off and discarded.
7. In reheating the steel, particular care must be taken to avoid all danger of causing internal rupture of the metal.

In any case, to fill the requirements will demand much care and labor, and constant attention, to insure the billets being of the proper quality, and that they be properly and thoroughly worked into bars; in no other way will the metal sought be obtained, and from experiences had, it is believed that due attention to the stipulations will produce a steel such as is required, and one much better adapted than those obtained heretofore to the purpose for which it is to be used.

Manufacturers who may intend to submit proposals will prepare and send to the armory, at once, for test, a sample of from 600 to 800 pounds (sufficient for 100 barrels) of the steel they may propose to furnish; for this sample payment will be made at the price bid.

Of any sample that may be found satisfactory, 100,000 pounds or more may be ordered, and contract may be made with two or more bidders for such an amount.

The party or parties to whom award may be made will be required to enter into the usual written contract, to be executed within ten days after receipt, with proper bond, and shall therein agree to make good, by deduction from cost of metal furnished, all loss to the United States for material, labor, and tools expended on inferior metal rejected, that may exceed 3 per cent of the amount received.

The Ordnance Department will reserve the privilege of sending an inspector to witness each operation of manufacture, and every facility must be given him for

verifying the compliance with the specifications, and failure to meet the requirements will be sufficient cause for the rejection of the material.

Bidders will please state by what process the steel will be made, within what time, after notice of the acceptance of bid, the first delivery could be made, and at what rate thereafter it could be furnished.

In order to test more fully the adaptability of nickel steel for use in barrels, 200 forms were procured of the Bethlehem Iron Company, the same as No. 47, Table I, Report Chief of Ordnance, 1896.

From these 112 barrels were obtained, 88 having been rejected at different stages, as follows, viz:

Seams, when received	22
At drilling, hard spots	20
At drilling, rough	8
At turning, not circular	10
At turning, seams	4
At reaming, rings	*9
At reaming, cuts	*1
At reaming, seams	1
At reaming, scratches	*1
At reaming, large	*1
At rifling, scratches	*1
At brazing, sight stud would not adhere to metal of barrel	10

Of the above, 13, marked *, may have been chargeable entirely to the workmen and tools. All the others were considered due to inherent qualities of the metal. More difficulty was experienced in machining these barrels than with simple carbon steels, and the great difficulty which exists in producing this metal uniform in structure and free from seams that may be found on the surface or within the forgings gives little encouragement to the view that such steel should at this time be tried further.

Two samples of crucible steel have been tested, 77 and S-1, Table I, the former being that made by the Sanderson Steel Company of England, and used for barrels by the English Government, and the latter that made by the branch of that company in the United States.

It is thought to be almost impossible to obtain with crucible steel the high tensile strength and elastic limit desired, with a high contraction, and probably in no case so high properties as with Bessemer steel. The low contraction is supposed to be due principally to the high proportion of silicon in such steels. An excellent fracture is found in these steels, and some barrels made and ruptured at proof split open and did not break into pieces, showing a very tough metal. Further trials are being made with this metal to determine its real value.

The results of the tests made during the year are embraced in four tables appended.

No. I.—Samples of steel.
No. II.—Barrels treated after rolling.
No. III.—Finished barrels, treated.
No. IV.—Analyses.

Your instructions of December 17, 1896, that experiments should be made to test the application to the rifle barrel of the Rodman principle of cooling from the interior were undertaken at an early date and proceeded with slowly, as the steel then in use was not of sufficiently uniform quality to test the true value of the process. Now that a more uniform and more reliable metal has been obtained, the experiment will be resumed and careful tests made, both here and with barrels to be sent to Watertown Arsenal.

The method now being followed of heating and cooling the barrels differs from the Rodman process in only that the barrels are removed

from the furnace before being cooled, instead of the source of heat being withdrawn and the heat of the furnace being allowed to sustain longer the heat in the metal. Barrels cooled in both ways will be thoroughly tested, as the former is much the more advantageous in manufacture, if the object sought can be accomplished to a sufficient degree.

In order to make more thorough tests of the barrels from different steels, some cartridges have been prepared, by your authority, giving a pressure of 100,000 pounds.

From the steel in use at the beginning of the year, eight rifles were fired with these cartridges; two burst at the first round, three were fired 10 rounds each, two 20 rounds each, and one 100 rounds without bursting any of the six and only causing an enlargement of the chamber, which occurred at the first fire, with little increase thereafter. The enlargement was sufficient to change the taper of the chamber and to render it necessary to drive the cartridge shell out with a ramrod, the extractor failing to do the work. This shows that should such an excessive pressure be accidentally produced, if the barrel be not burst the chamber will be so enlarged that the arm can no longer be conveniently used.

Experiments have also been made to determine the extent of the erosion of barrels of different steels. There were employed barrels of nickel steel, of open-hearth steel, of Bessemer steel, and of Bessemer annealed in air and by oil through the bore. In each case 5,000 rounds were fired, in groups of 500 rounds fired in thirty minutes. So soon as the test of some barrels cooled with oil, now being fired, may be completed, a full report will be submitted.

The accompanying instructions for U. S. magazine arms, caliber .30, in the hands of troops, have been prepared at the armory and distributed to all companies of troops in the service.

INVENTIONS EXAMINED.

During the year the following designs have been presented by inventors and examined and reported upon under instructions from you: September 26, 1896, W. B. Farwell, of San Francisco, Cal., magazine arm; January 16, 1897, William M. Piatt, of West Liberty, Ohio, automatic machine gun; April 7, 1897, J. H. Hanson, of Crystal Falls, Mich., magazine arm; April 17, 1897, Robert Gaskin, of St. John, New Brunswick, sight for small arms; June 9, 1897, J. A. Kennedy, of Washington, D. C., sight for small arms.

Respectfully, your obedient servant,

A. MORDECAI,
Colonel, Ordnance Department, U. S. A., Commanding.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

(10592—Enc. 9)

TABLE I.—*Samples of steel tested to determine those suitable for rifle barrels, caliber .30.*

No.	Date.	From whom.	Kind.	Designation.	Tenacity.	Elastic limit.	Elongation under maximum stress.	Elongation after rupture	Contraction.	Broken surface.	Sectional area of specimen.	Remarks.
					Pounds.	*Pounds.*	*Per ct.*	*Per ct.*	*Per ct.*		*Sq. in.*	
98	1896. Oct. 6	Sanderson Steel Co.	Tool steel	S	115,920	49,000	5	6	15	Fine granular	0.25	One experimental bar received.
99	Oct. 21	Midvale Steel Co.	Open-hearth steel, special grade.	61-S	132,480	72,000	10⅜	15	33.5	Silky, with fine granulation near circumference.	.25	
100	Dec. 26	....do	Nickel steel	65	97,100	67,000	14⅛	21⅛	46.2	Fine silky, cup-shaped.	.2	Properties low.
101	...do	The Spaulding & Jennings Co.	Bessemer steel	67	115,520	67,000	12⅛	17	33.5	Silky, with fine granulation at circumference.	.25	
102	...do	....do	....do	67	116,100	68,000	11⅜	17⅜	37.1	Fine silky, with trace of granulation.	.2	
103	1897. Feb. 13	....do	....do	68-1st heat	127,050	69,000	10⅜	13	23.9	Fine granular, radiating from silky spot at center.	.2	
104	...do	....do	....do	68-2d heat	125,000	74,000	6⅛	16⅛	37.1	Silky, with fine granulation, cup-shaped.	.2	
105	...do	....do	....do	68-3d heat	119,700	67,000	6⅜	15⅛	34	....do	.2	
106	...do	....do	....do	68-4th heat	129,850	76,000	6⅛	14⅜	30.7	....do	.2	
107	Mar. 3	....do	....do	68-5th heat	124,500	74,000	10⅜	15⅛	34	Silky, with fine granulation.	.2	
108	...do	....do	....do	68-7th heat	115,150	70,000	11⅛	16⅛	37.1	....do	.2	
109	Apr. 2	....do	....do	68-8th heat	120,350	70,000	10⅛	17⅛	40.3	Fine silky, cup-shaped	.2	
110	...do	....do	....do	68-9th heat	123,400	72,000	10⅛	15⅜	37.1	Silky, with fine granulation, cup-shaped.	.2	
111	...do	....do	....do	68-11th heat	120,000	73,000	10	16⅜	46.2	Fine silky, cup-shaped	.2	
112	Apr. 10	....do	Bessemer steel, new product.	69-1st heat	121,300	73,000	11⅛	17⅛	46.2	Fine silky.	.2	
113	...do	....do	....do	70-2d heat	129,000	73,000	8⅛	13⅛	20.5	Fine granular silky, eccentric spot.	.2	
114	...do	....do	....do	71-3d heat	123,250	69,000	7	16⅜	40.3	Fine silky	.2	
115	Apr. 17	....do	Bessemer steel, new product, 71-3d heat, rolled to 1.15-inches diameter.	72	122,450	75,000	10⅛	18⅜	49.1	Fine silky, cup-shaped	.2	
116	May 6	....do	Bessemer steel, No. 72, rolled to 1.09-inches diameter.	73	136,550	78,000	10⅛	16	43.3	....do	.2	

TABLE I.—*Samples of steel tested to determine those suitable for rifle barrels, caliber .30*—Continued.

No.	Date.	From whom.	Kind.	Designation.	Tenacity.	Elastic limit.	Elongation under maximum stress.	Elongation after rupture	Contraction.	Broken surface.	Sectional area of specimen.	Remarks.
	1897.				*Pounds.*	*Pounds.*	*Per ct.*	*Per ct.*	*Per ct.*		*Sq. in.*	
117	May 6	The Spaulding & Jennings Co.	Bessemer steel, No. 73, "Box annealed" by S. & J. Co.	74	123,100	77,000	10⅔	17	43.3	Fine silky	0.2	
118	June 26	....do	Bessemer steel, analysis imitation of sample No. 7, page 73, report of Chief of Ordnance, 1895.	75-1st heat	119,900	77,000	10.83	17	37.1	Fine silky, dark gray, cup-shaped.	.2	
119	July 23	....do	....do	75-3d heat	121,150	75,000	10⅓	18⅔	43.3	Fine silky, cupped ends.	.2	
120	...do	....do	Bessemer steel, special, same as 75-1st and 3d, with one-half the ingot discarded.	75-8th heat S.	118,050	74,000	11⅓	19	46.2	....do	.2	
121	...do	Midvale Steel Co.	Open-hearth steel, analysis imitation of sample No. 6, page 73, report of Chief of Ordnance, 1895.	76	117,700	75,000	10	18⅔	46.2	....do	.2	
122	...do	Sanderson Steel Co.	Crucible steel, imported, same as used in English barrels.	77	90,650	60,000	15	23	40.3	Silky, with fine granulation, cupped ends.	.2	1,000 pounds for trial.
123	...do	....do	Crucible steel, American, imitation of No. 77.	S. 1	113,950	67,000	12⅓	17⅔	30.7	Fine silky, cupped ends.	.2	

All bars not otherwise specified had diameter of 1.4 inches.

SPRINGFIELD ARMORY, MASS., *August 27, 1897.*

TABLE II.—*Tests of rifle-barrel steel, subjected to different treatments after rolling.*

Date.	Treatment.	Marks. a	Sectional area.	Tenacity.	Elastic limit.	Elongation under maximum stress.	Elongation after rupture.	Contraction.	Appearance of fracture.
			Sq. inch.	*Pounds.*	*Pounds.*	*Per cent.*	*Per cent.*	*Per cent.*	
1896. Dec. 26	Regular stock, annealed in charcoal	49-B	0.25	106,680	59,000	12⅓	16	27.6	Fine granular, from spot near center.
		49-M	.2	107,050	62,000	12	16⅔	34	Silky, with fine granulation.
1897. Feb. 23	Stock No. 63, page 58, report of Chief of Ordnance, 1896, annealed in charcoal.	63-B	.2	108,000	57,000	13⅓	17⅓	27.4	Do.
		63-M	.2	112,000	64,000	11	17	37.1	Fine silky, cup-shaped.
Mar. 3	Stock No. 68-2, annealed in charcoal	68-2 C	.2	117,900	66,000	10⅔	13⅓	23.9	Silky, with fine granulation.
3	Stock No. 68-2, annealed (cooled) in air	68-2 A	.2	127,700	71,000	10⅔	16⅓	37.1	Fine silky, trace of granulation, cupped ends.
Apr. 2	Stock No. 68-5, annealed in charcoal	68-5 C	.2	119,550	69,000	7	15⅔	34	Fine silky, dark gray.
2	Stock No. 68-5, annealed (cooled) in air	68-5 A	.2	128,050	76,000	9⅔	16⅔	43.3	Fine silky, cupped ends.
10	Stock No. 69-1, annealed in charcoal	69-C	.2	109,150	56,000	9	12⅓	16.9	Fine granular.
10	Stock No. 69-1, annealed (cooled) in air	69-A	.2	120,150	68,000	9	16⅔	43.3	Fine silky.
10	Stock No. 70-2, annealed in charcoal	70-C	.2	116,450	60,000	10⅓	13	23.9	Fine granular.
10	Stock No. 70-2, annealed (cooled) in air	70-A	.2	130,400	73,000	10⅓	12	20.5	Fine granular, from dull silky spot near circumference.
10	Stock No. 71-3, annealed in charcoal	71-C	.2	111,800	57,000	11⅔	14⅓	16.9	Fine granular, from point in circumference.
10	Stock No. 71-3, annealed (cooled) in air	71-A	.2	126,550	68,000	9⅔	11	13.2	Fine granular, radiating from circumference.
17	Stock No. 72, annealed in charcoal	72-C	.2	103,200	55,000	11⅓	17⅔	37.1	Silky, trace of granulation.
17	Stock No. 72, annealed (cooled) in air	72-A	.2	126,050	65,000	9⅓	12	13.2	Fine granular.
19	Barrel No. 70 C, raised to dark red heat in barrel furnace and annealed (cooled) in air.	70-X	.2	118,300	76,000	12	17⅔	49.1	Fine silky, cup-shaped.
27	Stock No. 68-8, annealed (cooled) in air (duplicate)	68-8 A	.2	127,200	71,000	11	15⅓	37.1	Silky, with fine granulation.
		68-8 A	.2	127,550	72,000	10	15⅓	37.1	Do.
27	Barrel No. 68-8 A, reheated in barrel furnace, annealed (cooled) in air (duplicate).	68-8 B	.2	108,800	69,000	12	19⅓	49.1	Fine silky, cup-shaped.
		68-8 B	.2	119,050	70,000	11⅓	19	51.9	Do.
27	Barrel No. 68-8 A, reheated in charcoal fire for 9 inches at butt end, annealed (cooled) in air (duplicate).	68-8 C	.2	114,450	65,000	11	17⅔	49.1	Do.
		68-8 C	.2	118,900	71,000	12⅓	17	43.3	Fine silky, trace of granulation.
27	Barrel No. 68-8 A, reheated in gasoline furnace for 9 inches at butt end, annealed (cooled) in air (duplicate).	68-8 G	.2	118,400	65,000	10	14⅔	46.2	Do.
		68-8 G	.2	123,850	70,000	10	15	40.3	Do.

a B, breech. M, muzzle.

SPRINGFIELD ARMORY, MASS., *August 27, 1897.*

TABLE III.—*Test of finished barrels, caliber .30.*

[Three specimens taken out 120° apart.]

Date.	Description.	Specimen.	Sectional area.	Tenacity.	Elastic limit.	Elongation after rupture.	Contraction.	Appearance of fracture.
1897.			*Sq. inch.*	*Pounds.*	*Pounds.*	*Per cent.*	*Per cent.*	
May 6	From bright barrel No. 1	First	0.0197	120,100	67,000	16	51.8	Silky.
	....do	Second	.0199	119,400	62,810	16	52.3	Do.
	....do	Third	.0190	119,100	67,340	16	43.2	Do.
	From bright barrel No. 2	First	.0199	114,920	60,800	16	43.2	Silky, trace of granulation
	....do	Second	.0199	114,320	62,060	14	43.2	Do.
	....do	Third	.02	114,650	62,400	14	33.5	Silky, granular metal interspersed.
	From heated barrel No. 1	First	.02	120,700	75,500	21	52.5	Silky.
	....do	Second	.0201	119,950	60,150	19	52.7	Do.
	....do	Third	.0196	121,530	74,490	18	51.5	Do.
	From heated barrel No. 2	First	.0201	116,710	72,640	20	52.7	Do.
	....do	Second	.0199	113,820	64,320	19	52.3	Do.
	....do	Third	.0190	116,280	66,330	19	52.3	Do.

The barrels were from the steel 68–2, Table I.
The "bright barrels" were finished from 68–2 C, Table II.
The "heated barrels" were finished from 68–2 C, Table II, and then 9 inches at butt were raised to a red heat in a coal fire and allowed to cool in air.

SPRINGFIELD ARMORY, MASS., *August 27, 1897.*

TABLE IV.—*Chemical analyses of steels for rifle barrels—made at Watertown Arsenal.*

Date.	Metal tested.	Marks.	Carbon.	Manganese.	Silicon.	Sulphur.	Phosphorus.	Copper.	Nickel.
	Reports of Chief of Ordnance.								
1896.									
July 29	Table II, 1896	49	0.460	1.377	0.186	0.100	0.095	....	....
29	Table II, 1896	49-A	.500	1.220	.173	.102	.060	....	....
29	Table I, 1896	60	.555	1.313	.148	.120	.060	....	....
29	Table I, 1896	61	.530	1.274	.360	.055	.046	....	....
29	Table I, 1896	62	.422	1.900	.435	.065	.080	....	....
29	Table I, 1896	63	.534	1.421	.417	.115	.045	....	....
29	Table I, 1896	64	.541	1.614	.418	.075	.080	....	....
Oct. 21	Table I, 1897	61-S	.534	.988	.601	.059	.047	....	....
Dec. 26	Table I, 1897	65	.360	.700	.275	.026	.030	0.168	3.980
26	Table I, 1897	67	.515	1.124	.118	.055	.081	.127	.092
26	Table II, 1897	49	.520	1.058	.177	.096	.068	.199	.154
1897.									
Feb. 13	Table I, 1897	68-1	.475	1.530	.169	.088	.076	.271	.267
13	Table I, 1897	68-4	.480	1.662	.122	.107	.055	.250	.259
Mar. 3	Table I, 1897	68-5	.530	1.404	.166	.100	.076	.210	....
3	Table II, 1897	68-2 C	.530	1.441	.150	.072	.064	.245	....
3	Table II, 1897	68-2 A	.530	1.441	.150	.072	.064	....	....
Apr. 2	Table II, 1897	68-5 A	.585	1.420	.150	.107	.070	.138	.075
2	Table II, 1897	68-5 A	.609	1.456	.142	.091	.077	.142	.090
10	Table I, 1897	69-1	.540	1.213	.169	.080	.051	.191	.361
10	Table I, 1897	70-2	.590	1.400	.159	.074	.060	.183	.125
10	Table I, 1897	71-3	.545	1.581	.178	.077	.045	.095	.115
17	Table I, 1897	72	.506	1.777	.182	.074	.045	.279	.256
17	Table II, 1897	72-A	.495	1.762	.188	.077	.045	.285	.250
17	Table II, 1897	72-C	.509	1.788	.180	.075	.047	.287	.255
19	Table II, 1897	70-X	.564	1.592	.225	.080	.055	.167	.314
July 23	Table I, 1897	75-3	.565	1.200	.100	.080	.092	.159	....
23	Table I, 1897	75-S	.470	1.273	.138	.082	.083	.170	....
23	Table I, 1897	76	.503	1.609	.141	.077	.092	.043	....
23	Table I, 1897	77	.440	.550	.205	.047	.060	.020	....
23	Table I, 1897	S-1	.688	.530	.126	.025	.027	.033	....

SPRINGFIELD ARMORY, MASS., *August 27, 1897.*

INSTRUCTIONS FOR U. S. MAGAZINE ARMS, CALIBER .30—IN THE HANDS OF TROOPS.

PARTS WHICH ARE MOST LIABLE TO REQUIRE REPAIR.

Bayonet catch nut.—Works loose and is lost, if the end of the catch has not been well riveted over the nut.

Bolt.—In model 1892, may break at junction of handle and body, from metal having been burned in manufacture. Flange broken at front end, from defective cartridges. Countersink at front end scored or pitted by gas from defective primers.

Cocking piece.—Nose worn, from neglect to keep it lubricated.

Cut-off.—Thumb piece knocked off by blow, due to form.

Ejector.—Bent or broken from blow of cleaning rod, forced without proper care through the bore.

Extractor screw.—Lost by working loose.

Gate.—Lug broken off by escape of gas into the magazine, due to defective cartridges.

Hinge bar.—Head broken off from blow, or attempt to withdraw it improperly.

Lower band swivel and screw.—Screw if not riveted in place works loose, and with swivel is lost.

Safety lock.—Model 1892, thumb piece breaks off from blow, or spindle may break from weakness. Model 1896, thumb piece breaks out where drilled for spring and spindle. (This part has been strengthened.)

Stacking swivel and screw.—Screw, if not riveted in place, works loose, and with swivel is lost.

Stock.—Bruises, cuts, pieces chipped from different points. Broken at "small."

Striker.—Point burned by defective cartridges.

THE REPLACING OF BROKEN PARTS.

Butt-plate cap pin.—This pin has both ends riveted on the lugs; the burr on one end must be filed off and the pin driven out with a drift; when a new pin is put in, its ends must be upset with light blows of a hammer.

Cut-off.—If, when the thumb piece is broken off, the spindle of the model 1892 remains in the hole, it can be removed by a knife or small screw-driver, first removing the side plate if found necessary. To assemble the new one, model 1896, insert

its spindle, the thumb piece turned down, in the cut-off hole in the receiver, until the spring spindle strikes the receiver; then, with a blade of the screw-driver, force the spring spindle into its hole in the thumb piece and push the cut-off into place. Care must be taken that the flattened and not the straight sides of the spring spindle bear on the curved surface of the recess in the receiver.

Ejector.—Take out the side-plate screw, remove the side plate, withdraw the ejector pin with point of a knife or small screw-driver; the ejector will drop out if the gun be turned over. A new ejector can then be inserted and the same pin, the side plate and its screw, returned to their places

To remove the side plate without injuring the stock, it is necessary to turn the guard screws out partially, and relieve the close binding of the receiver in the stock.

After the side plate has been replaced, its screw and the guard screws must be screwed up firmly, care being taken not to injure their heads.

Extractor.—Place the sleeve on a wooden block with the extractor rivet over a hole in the block, drive the rivet out with a punch, smaller in diameter than the rivet, remove the old and enter a new extractor to the proper distance in its slot in the sleeve, then insert the rivet in its hole and drive it into place by light blows of a hammer.

In the model 1892 arms the extractor screw is removed and replaced, a screw-driver only being needed, but it must be used with care, and the point of the screw must be entered accurately in the thread of the hole in the sleeve.

Front sight.—As the left end of the sight pin is upset, this burr must be removed with a small file, and the pin then driven out from the left side with a small drift. The new sight having been put in the slot, a new pin must be used, inserted from the right side, and, when in place, the left end should be upset with blows of a light hammer. The sight pin is tapering, and its small end should be inserted first.

Lower band swivel screw.—This screw when in place has its end upset and riveted over the band ear. It should never work loose, if properly assembled, and when it has to be removed to replace an injured swivel, the burr on the end should be filed off and the screw taken out, the end being again upset when the screw has been returned to its place.

Rear sight base.—When it may be necessary to remove the rear sight for repairs, it must be done by one thoroughly familiar with the use of the screw-driver, to prevent injury to the head or point of the base screws.

Before replacing the base, the barrel, bottom of the base, and the screw holes in the barrel should be carefully cleaned; the screws should be started so as to enter freely the holes in the barrel, and they must be screwed in firmly against the base, but not with sufficient force to strip the threads or break the head.

Safety lock.—The thumb piece of the safety lock, model 1892, being broken off, the spindle can be removed by taking out the safety lock pin. With the model 1896, the spindle under the same conditions will drop out; should one side of the thumb piece be broken out, the safety lock must be turned till the thumb piece stands vertical, 90° from its normal position, and then pulled directly to the rear.

The pin in the model 1892 can generally be driven out from the left side with a small steel drift, though as that end is upset, it may be necessary to first remove the burr with a file. When replacing a broken safety lock by a new one, care must be taken that one of the proper pattern for the position of the hole in the sleeve is selected; the pin, after being driven in from the right side of the sleeve, must have its small end upset.

To assemble the safety lock, model 1896, introduce the point of the tang of a small file, or any tool of similar size and shape, between the thumb piece and the spindle, thus compressing the spring and forcing the spring spindle into the thumb piece; insert the lock spindle in its hole in the sleeve, the thumb piece being held vertical, push the safety lock forward, gradually withdrawing the tool.

Sear.—To assemble this in the receiver, insert the spring in its hole in the sear, start the hinge of the sear into its seat in the receiver, and with a blade of the screw-driver compress the spring in its hole until the sear can be pushed into place.

Stacking swivel screw.—This must be treated in exactly the same manner as the lower band swivel screw.

Trigger pin.—The small end must be entered from the right side of trigger, and, when in place, upset on left side.

INJURIES WHICH DO NOT RENDER PARTS UNSERVICEABLE.

Bolt.—The entire flange at the front end may be broken off, except a small portion on the opposite side from the guide rib which is required to support the head of the empty case and cause the case to be drawn to the rear sufficiently far to be acted upon by the ejector.

If the automatic ejection be not considered, the entire flange may be dispensed with.

Butt plate.—Bruises, cuts, or wearing.

Butt swivel.—Bent.
Cocking piece.—Moderate wearing of nose.
Extractor.—Moderate wear or break of edge of hook. Loss of spring.
Guard.—Bent, bruised, or cut.
Receiver.—Metal broken from the left side at cut-off hole. Guide lip lost, bent, or loose.
Side plate.—Edges broken. Cut through thin part at shoulder, near screw hole.
Swivel bar of carbine.—Bent.

USING AN ARM WHEN CERTAIN PARTS OF THE BREECH AND MAGAZINE MECHANISMS MAY BE WANTING.

The parts not essential, or only so to a degree, are the ejector, the extractor spring, extractor pin model 1896, safety lock, cut-off, guide lip, gate, carrier, follower, side plate.

The empty cases drawn to the rear by the extractor can be removed from the receiver by the finger or by turning the arm on one side.

The safety lock being merely a precautionary device, its absence does not affect the firearm.

The absence of the cut-off does not affect the use of the arm as a single loader if the magazine be kept empty or the feeding can be done through the magazine, which only prevents the latter from being held full in reserve.

The want of one or more of the last four parts enumerated above only prevents the use of the magazine, but in no way affects the arm as a single loader.

The soldier should be taught to appreciate these facts.

PRECAUTIONS.

1. Complaints have not infrequently been made that a mainspring is too weak to perform its office, when the fault rested with the soldier, who in sighting inadvertently raised the bolt handle with his hand before pulling the trigger, and thus caused the force of the spring to be expended in closing the bolt, instead of in exploding the cartridge.

The mainspring for rifle, model 1892, is shorter than that for the model 1896 and the carbine.

2. The cocking piece, to prevent wear, must be kept slightly oiled.

3. In assembling the gate, observe that the magazine spring has its front end on top of the heel of the carrier, and not beneath it.

4. The side plate, when removed, must be returned firmly to its bearings or the width of the cartridge way will be too great to cause the proper feeding of the cartridges.

5. When firing many successive rounds, note must be taken that powder residue and unburned grains do not collect and pack in the locking-lug recess in the receiver, as this will interfere with the perfect closing of the bolt. Such accumulations can be blown out from time to time or when packed removed by a knife or the screw-driver.

6. Except when repairs are needed, the following parts will constantly be injured if allowed to be dismounted by the soldier for cleaning, and when repairs are necessary they should be removed only by a company artificer or one familiar with the handling of tools and delicate mechanisms, viz., cut-off, extractor, front sight, band swivel screw, rear sight, safety lock. The rear sight is accurately constructed and fitted carefully to the barrel, and the adjustment of its parts must be preserved to insure correct aiming. If the soldier be permitted to remove these parts they will become worn and injured and the closeness of their fit be destroyed.

7. Unless the screw-driver be handled carefully and with some skill the screws are sure to be injured either at the head or thread.

SPRINGFIELD ARMORY, *January 14, 1897*.

APPENDIX 7.

REPORT OF FIRINGS WITH U. S. MAGAZINE RIFLE AND CARBINE, CALIBER .30, FOR ACCURACY, DRIFT, ETC., AT THE SPRINGFIELD ARMORY, MASS.

SPRINGFIELD ARMORY, MASS., *October 8, 1897.*

SIR: I have the honor to submit herewith the drift, the deviation of the bullet due to a 1-mile wind normal to the plane of fire, the radius of circle of shots or accuracy, and the elevation of the service sight at ranges from 100 to 1,800 yards, inclusive, of the U. S. magazine rifle, caliber .30.

The drift at each range was found by selecting the horizontal deviations of those targets, made in a calm or in a very light wind and tabulating their average. (See enclosure 1.) A careful study and examination of the target records will show the average horizontal deviations at 200, 500, 800, 1,200, and 1,800 yards are most reliable, and as it is a rule that the drift varies from range to range according to some approximately regular order of differences the drift at these ranges was taken as correct, and at the other ranges it was found by establishing an order of differences that satisfied the conditions. From 1,400 to 1,700 yards, inclusive, no satisfactory records were obtained, but from them it appears evident that up to 900 yards the drift increases more rapidly than at greater ranges. In nearly every record of the rifle fired in a calm the center of impact is to the left, i. e., the drift is to the left. The difference between the average of the drift of the records and the computed drift at 100, 300, 400, 600, 700, 900, 1,000, and 1,100 yards is sufficient evidence of the correctness of the results at those ranges.

By applying the drift at each range to the horizontal deviation of each target and dividing the result by the component of the wind normal to the range, and by finding the average of these quotients, the deviation due to a 1-mile wind normal to the plane of fire will be found for each range.

Owing to the large number of targets at each range no records of the calculations are submitted.

In finding the radius of circle of shots or accuracy the same method was followed. The results at 100, 500, 900, 1,000, and 1,600 yards, being most reliable, were taken as fixed. The differences between the averages and the selected accuracy are very slight except at 1,200, 1,300, 1,400, and 1,500 yards, inclusive, but the average at 1,600 yards of five uniform targets made with a muzzle rest compels its selection as correct.

When firing, preliminary shots were always fired to obtain, if possible, the correct elevation for the range, and the elevation was carefully measured and reduced to degrees and minutes.

The elevations given were found from the rifle and service sight and are the correct elevations for graduating the sight. They differ materially from the calculated elevations, but experience with the model 1892 sights, the graduations of which corresponded very closely with the calculated angles of elevation, shows that the results here given

approximate far more closely to the correct elevations than do those obtained by calculation.

As soon as the target records can be copied the records will be submitted with a full report of the firings made this year.

Respectfully,

TRACY C. DICKSON,
Lieutenant, Ordnance Department, U. S. A.

The COMMANDING OFFICER.
(7746—Enc. 60)

[First indorsement.]

SPRINGFIELD ARMORY, MASS., *October 9, 1897.*

Respectfully forwarded to the Chief of Ordnance, U. S. A.

Similar data for the U. S. magazine carbine, caliber .30, is being prepared and will be forwarded so soon as completed.

A. MORDECAI,
Colonel, Ordnance Department, U. S. A., Commanding.

U. S. magazine rifle, caliber .30.

Range.	Radii of circles of shots or accuracy taken from target records.							Accuracy or radius of circle of shots.
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	Average of the records.	
Yards.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
100	1.34	1.28	1.14	1.04			1.2	1.2
200	2.41	3.09	2.24	1.64			2.3	2.1
300	3.53	4.03	3.12	3.49			3.5	3.3
400	5.35	4.54	4.63	5.06			4.9	4.7
500	5.94	6.17	5.84	6.44	6.67		6.2	6.2
600	5.75	9.11	7.45	7.95	8.79		7.8	7.7
700	11.81	11.95	11.62	9.61	9.75		10.9	9.3
800	14.61	13.1	12.34	9.47	13.98	13.19	12.8	11.1
900	12.37	13.58	13.06				13.0	13.0
1,000	13.72	15.47	16.81	13.69	14.62		14.8	14.9
1,100	18.11	18.47	12.65				16.4	16.8
1,200	28.39	30.51	22.77	19.36			25.25	19.1
1,300	27.05	35.07	28.57	33.08			30.94	21.8
1,400	41.38	32.42	36.24	37.54			36.89	25.0
1,500	41.77	54.11	26.25	34.39			39.13	28.7
1,600	27.92	33.31	30.72	36.23	36.56		32.98	33.0
1,700	32.64	36.06	38.30				35.66	38.0
1,800	27.54	46.84	53.14	59.06			46.64	44.0

Range.	Drift or deviation to the left when fired in a calm.					Drift to the left.
	Target records.				Average of the records.	
	No. 1.	No. 2.	No. 3.	No. 4.		
Yards.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
100	3.39	1.69	3.8	1.07	2.48	2.5
200	3.41	4.11			3.76	3.7
300	5.57	6.19	3.17		4.97	5.1
400	5.62	6.57			6.09	6.7
500	9.7	7.88	8.54		8.7	8.7
600	13.1	7.5	7.8	13.43	10.46	11.1
700	(a)	(a)	(a)	(a)	(a)	14.0
800	20.3	15.0	16.2		17.2	17.2
900	21.4	18.7			20.05	20.7
1,000	23.9	25.24			24.57	24.0
1,100	23.0	19.7	41.0		27.9	26.2
1,200	25.0	31.81			28.4	28.4
1,300	35.9				35.9	30.6
1,400	(a)	(a)	(a)	(a)	(a)	32.8
1,500	(a)	(a)	(a)	(a)	(a)	35.0
1,600	29.4	24.5			26.95	37.2
1,700	26.75				26.75	39.3
1,800	41.17	41.65			41.41	41.4

a No record.

U. S. magazine rifle, caliber .30—Continued.

Range.	Drift to the left.	Deviation of the bullet due to a one mile wind normal to the plane of fire.	Accuracy or radius of circle of shots.	Elevation found from service sight.	
Yards.	*Inches.*	*Inches.*	*Inches.*	*Degrees.*	*Minutes.*
100	2.5	0.6	1.2		
200	3.7	1.3	2.1		
300	5.1	2.3	3.3		9
400	6.7	3.5	4.7		16
500	8.7	4.9	6.2		24
600	11.1	6.6	7.7		34
700	14.0	8.7	9.3		45
800	17.2	11.1	11.1		57
900	20.7	13.9	13.0	1	11
1,000	24.0	17.0	14.9	1	26
1,100	26.2	20.5	16.8	1	42
1,200	28.4	24.4	19.1	1	59
1,300	30.6	28.8	21.8	2	17
1,400	32.8	33.7	25.0	2	36
1,500	35.0	39.1	28.7	2	56
1,600	37.2	45.0	33.0	3	18
1,700	39.3	51.6	38.0	3	42
1,800	41.4	58.9	44.0	4	9

SPRINGFIELD ARMORY,
Springfield, Mass., October 22, 1897.

SIR: I have the honor to submit the following report on the additional firings made during this summer for the determination of the drift, deviation of the bullet due to wind, accuracy and elevations of the United States magazine rifle, caliber .30. The *results* were submitted in report of October 8, 1897.

The range used is about 7 miles from the armory, and is the same that was used during last November and December. A camp was established on the range, so the men could be ready from sunrise until sunset to fire whenever a calm occurred. Firings were also made with the wind blowing to determine the deviation due to wind. The camp was established May 11 and removed August 20, because the wind blew continuously.

The recommendation made in my report of February 10, 1897, to discontinue the use of the telescopic sight having been approved, two rifles, No. 36026 and No. 36208, with service sights, were used. These rifles had been previously used at Sandy Hook during 1896.

Firings were also made with the carbine, but before sufficient data therefor could be obtained it became advisable to abandon the camp until the weather became less windy. Firing with the carbine has been resumed and upon its completion the results will be submitted.

The anemometer was about 500 yards from the target and about 30 feet above the ground. Frequently the anemometer cups would not be turning, the flags at 400, 900, and 1,400 yards would hang quietly, and to all appearances there was a dead calm, but when a fire was built the rising smoke would indicate a breeze or a general movement of the atmosphere of sufficient strength to materially affect at long ranges the deviation of the bullet. This shows that at long ranges, beyond 1,200 yards, the lightest breeze is sufficient to destroy the reliability of a target, and that the greatest possible attention must be given to any motion of the atmosphere.

The records of all the targets made at each range are inclosed herewith. In determining the drift, etc., the target records submitted on

February 10, 1897, were used with those herewith, except that the targets made with the telescopic sight (rifles No. 15849 and No. 15862) were not considered as reliable as those made with the service sight.

The anemometer record sheets are also submitted, in order that the great delay in determining these results may be attributed to the principal causes, viz, lack of calms.

On the left side of each rifle a spirit level was placed and adjusted so as to be at right angles with the sight leaf when raised. This enabled the rifle to be held each shot so the line of sight and axis of the bore would both lie in the same vertical plane. The ammunition used was marked "Velocity at 53 feet, 1,963 feet, February 13, 1897."

The methods by which the drift, deviation, accuracy, and elevation were obtained were explained in my report of the 8th instant.

In the beginning of all this firing two rifles, No. 15849 and No. 15862, were made to be sighted by a telescope. It was recognized that unless the attachments could be made so the axis of the bore and line of colimation of the telescope would always be contained in parallel vertical planes the targets made by them would be valueless. When completed they were assembled in a lathe in the machine shop and were made as nearly parallel as mechanical means permitted. I assumed all to be correct, and on January 16, 1896, began firing through screens in a calm, and found that at 1,000 yards the center of impact of a group of 10 shots was 40.3 inches to the left. The fact that the drift was so much to the left convinced me that the adjustment was incorrect.

One hundred feet was as close as an object would be distinctly seen through the telescope, so I placed the muzzle of the gun 100 feet from the target and adjusted the aim until the cross hairs covered a cross made on a paper which was attached to the target. The parallelism of the telescope and rifle was adjusted until the center of impact of 10 shots was 2 inches to the right of the vertical line on the target—2 inches being the distance between the axes of the telescope and bore called for by the drawing.

It was found necessary to make this adjustment at frequent intervals, the parallelism being easily destroyed in spite of the care taken to preserve it. This is one reason why the records obtained with rifles No. 15849 and No. 15862, which were always fired from the fixed rest and aimed by the telescope, are considered far less reliable than those made with rifles fired from the shoulder with a muzzle rest and aimed with the service sights, and another is that a rifle held in a fixed rest will not, in general, give the same results as when fired from the shoulder.

The following results were obtained on the water-shop pond at 1,000 yards with rifle No. 15849 fired from the fixed rest and aimed with the telescope after the adjustment above described:

Date.	Number of shots.	Deviation (left).	Wind.	
			Miles per hour.	O'clock.
1896.		*Inches.*		
January 16	9	18.7	4	6
January 21	10	17.2	3.7	6
January 23	22	12.2	7	6.30

These deviations were all to the left, as were those when firing in 1895, to correct the graduations of the rifle sight.

In order that the data upon which the left-handed drift is based may be readily examined, every target made with the United States magazine rifle, caliber .30, at each range in a calm since firings were commenced for the determination of the drift, etc., is given in the table A hereto appended.

Only 1 of the 61 targets made in a calm has its center of impact, or drift, to the right, and that is at 300 yards, and was made with rifle No. 15849, October 30, 1896.

These target records show that the drift of at least the seven rifles fired is to the left.

The drift of the carbine is to the right. A rifle barrel was assembled in a carbine stock and fired at several ranges with regular rifles and carbines, but its drift was always to the left. See all records in the table made with rifle No. 47824 in 1897.

The explanation of why the drift of the rifle is to the left and that of the carbine is to the right must be looked for in the difference in length of the bores and the difference in the muzzle velocities. When time permits, it is recommended that firings be made with barrels of different lengths from 22 to 30 inches, as it is evident that there must be a length between these limits that would have no drift.

The elevations given in report of October 8, 1897, represent the average elevation at each range, as at nearly every range firing was done in all kinds of light weather and atmospheric conditions and by different individuals.

As the elevations obtained from the service sight differ from those calculated by differences that increase with the range, an attempt will be made to find experimentally whether these differences are due to jump.

Respectfully,

T. C. DICKSON,
Lieutenant, Ordnance Department, U. S. A.

The COMMANDING OFFICER.
(7746—Enc. 64)

Number of piece.	Caliber.	Date of firing.	Number of previous rounds fired.	Number of shots fired.	Number of shots in target.	Elevation.	Vertical deviation. Above.	Vertical deviation. Below.	Horizontal deviation. Right.	Horizontal deviation. Left.	Mean vertical deviation.	Mean horizontal deviation.	Mean absolute deviation or radius of circle of shots.	Weather.	Light.	Wind. Miles per hour.	Wind. Direction.	Component of wind normal to range.	Component of wind parallel to range.	Remarks.
RANGE, 100 YARDS.																				
		1897.				° ' ''	''	''	''	''	''	''	''				O'clock.			
36026	.30	May 18	332	11	10	0 8 4	7.39	....	....	4.41	1.21	1.17	1.68	Fair ...	Good ..	Light.	5.00	....	....	
36208	.30	May 18	342	10	10	8 12	8.66	....	....	3.39	.74	.87	1.14	Fair ...	Good ..	Light.	5.00	....	....	
36026	.30	July 6	1,479	10	10	8 3	12.60	....	....	4.00	.76	1.04	1.28	Fair ...	Good ..	2	3.00	2	....	
36208	.30	July 6	1,269	10	10	8 12	12.9	....	....	5.60	1.14	1.28	1.71	Fair ...	Good ..	2.5	3.00	2.5	....	
36026	.30	July 16	1,607	10	10	8 3	11.2	....	....	4.3	1.08	.94	1.42	Fair ...	Good ..	3	....	....	....	Calm.
36208	.30	July 16	1,363	11	10	Lost.	12.1	....	....	5.8	1.34	.94	1.63	Fair ...	Good ..	5	....	....	....	Calm.
47824	.30	June 23	110	10	10	....	10.7	....	....	3.8	1.46	1.14	1.85	Fair ...	Good ..	0	10.30	....	....	Calm.
47824	.30	June 6	311	10	10	....	5.3	....	....	4.1	1.28	.42	1.34	Fair ...	Good ..	2	4.00	1.73	....	
RANGE, 200 YARDS.																				
36026	.30	May 17	298	10	10	8 4	8	....	....	3.41	2.98	2.40	3.82	Fair ...	Bright.	Lost.	9.00	....	....	Calm.
36208	.30	May 17	310	10	10	8 12	14.56	....	....	4.47	3	3.17	4.37	Fair ...	Bright.	Lost.	9.00	....	....	Calm.
RANGE, 300 YARDS.																				
36208	.30	May 12	254	12	10	8 13	4.05	....	....	20.79	4.14	4.54	6.14	Fair ...	Poor...	13	3.00	13	....	
36026	.30	May 17	269	17	10	14 18	....	0.93	....	3.17	3.11	2.57	4.03	Fair ...	Good ..	0	....	....	....	Calm.
36026	.30	May 17	308	12	10	8 56	....	5.94	....	6.19	4.50	3.38	5.62	Fair ...	Bright.	Lost.	....	....	....	Calm.
36208	.30	May 17	320	10	10	8 14	....	0.72	....	5.57	6.40	2.07	6.72	Fair ...	Bright.	Lost.	....	....	....	Calm.
47824	.30	June 26	130	10	10	....	....	5.10	....	7.2	5.54	4.82	7.34	Fair ...	Good ..	1.5	....	....	....	Calm.
RANGE, 400 YARDS.																				
36026	.30	May 18	343	11	10	17 30	1.31	....	....	20.67	5.37	5.07	7.38	Fair ...	Gray ..	Light.	5.00	....	....	
36208	.30	May 18	352	10	10	16 28	4.74	....	....	21.65	4.46	4.77	6.53	Fair ...	Gray ..	Light.	5.00	....	....	
36026	.30	July 6	1,469	10	10	15 11	....	3	....	17.3	6.52	3.44	7.37	Fair ...	Good ..	0	....	....	....	Calm.
36208	.30	July 6	1,259	10	10	16 27	10.1	....	....	16.7	4.96	5.44	7.36	Fair ...	Good ..	0	....	....	....	Calm.
36026	.30	July 16	1,597	10	10	15 11	....	.1	....	17.8	4.62	4.44	6.40	Fair ...	Good ..	4	3.00	4	....	
36208	.30	July 16	1,352	11	10	15 52	12.2	....	....	24.5	6.44	4.48	7.84	Fair ...	Good ..	2	8.00	2	....	
47824	.30	June 26	140	13	10	....	1.6	....	....	12.7	3.54	4.02	5.35	Fair ...	Good ..	0	....	....	....	Calm.
47824	.30	July 6	300	11	10	....	....	1.90	....	12.5	6.10	4.66	7.73	Clear ..	Good ..	0	1.00	....	....	

RANGE, 500 YARDS.

36208	.30	May 15	266	14	10	0 24 27		2.37	7.50		5.76	9.10	10.76	Fair....	Poor...	6	8.30	5.79		
36026	.30	May 17	286	12	10	26 49	4.41			20.40	3.09	5.34	6.17	Fair....	Good ..					Calm.
36026	.30	May 18	354	10	10	26 37		0.42		26.24	10.08	4.02	10.87	Fair....	Dark ..					Calm.
36026	.30	May 19	383	12	10	26 37		0.40	21.74		11.08	10.11	13.36	Fair....	Bright.	8	9.00	8.00		
36208	.30	May 19	373	10	10	26 8	17.01		16.13		5.63	6.01	8.23	Fair....	Bright.	8	8.30	7.72		
36026	.30	May 19	395	10	10	26 37	0.70			2.65	5.14	6.87	8.58	Fair....	Bright.	3.5	8.00	3.03		
36208	.30	May 19	283	10	10	26 8	6.60			14.82	9.28	11.21	14.56	Fair....	Bright.	3.5				Variable.
36026	.30	May 19	405	10	10	26 37	1.94		6.77		6.86	4.77	8.35	Fair....	Good ..	6	8.00	5.19		
36208	.30	May 19	393	11	10	Lost.	8.43			16.82	7.87	8.69	11.72	Fair....	Good ..	1				Variable.
36026	.30	June 16	1,210	10	10	28 58	10.50			9.70	6.94	6.4	9.44	Clear...	Foggy .	0				Calm.
36208	.30	June 16	1,039	11	10	Lost.	38.60			7.88	7.94	6.6	10.32	Clear...	Foggy .	0				Calm.
36026	.30	July 6	1,455	14	10	23 50	1.50			15.40	8.72	8.08	11.89	Clear...	Poor...	1				Lost.
36208	.30	July 6	1,246	13	10	24 26	9.10			9.80	4.8	3.5	5.94	Clear...	Good ..	1	9.00	1		
36026	.30	July 16	1,585	12	10	23 51	2.91			20.56	5.18	4.19	6.67	Clear...	Poor...	0				Calm.
36208	.30	July 16	1,341	11	10	24 12	16.3			27.8	6.00	6.18	8.61	Clear...	Poor...	0				Calm.
47824	.30	June 16	11	11	10			12.7		25.3	8.58	7.50	11.40	Clear...	Poor...	1	3.00	1		
47824	.30	June 28	153	14	10			0.7		21.7	10.56	6.46	12.39	Clear...	Poor...	2	3.00	2		
47824	.30	July 6	289	11	10			10.9		15.8	10.46	7.38	12.80	Clear...	Poor...		11.00			
47824	.30	July 16	374	11	10		7.3			12.8	8.86	6.08	10.74	Clear...	Poor...	0	1.00			

RANGE, 600 YARDS.

36026	.30	May 21	415	10	10	37 59	22.99			84.55	6.55	6.33	9.11	Cloudy.	Poor ...	12	3.30	11.5		
36208	.30	May 21	404	14	10	32 41	4.69			78.49	7.91	6.83	10.45	Cloudy.	Poor ...	14	3.30	13.5		
36026	.30	May 21	443	13	10	37 59	7.54			18.54	7.60	9.38	12.67	Cloudy.	Good.					Calm.
36208	.30	May 21	427	15	10	32 41	5.20			21.22	7.64	6.01	9.72	Cloudy.	Good...					Calm.
36026	.30	June 16	1,220	11	10	37 20	30.9			27.20	12.1	5.22	13.17	Foggy .	Hazy ..	1	4.00	.87		
36208	.30	June 16	1,050	11	10	32 40		3.2		18.30	9.58	9.8	13.70	Foggy .	Hazy ..	0.5	4.00	.43		
36026	.30	July 16	1,574	11	10	35 44	18.9			20.10	9.74	6.64	11.79	Clear...	Fair ...	1.5				
36208	.30	July 16	1,329	12	10	36 3	30.5			13.10	4.00	4.14	5.75	Clear...	Fair ...	1.5				
47824	.30	June 16	0	11	10		7.5			28.3	12.78	7.8	14.96	Clear...	Bright .	1	3.00	1		
47824	.30	June 29	367	10	10		2.3			7.8	11.98	5.1	13.02	Clear...	Bright .	1	9.00	1		Calm.
47824	.30	July 16	301	13	10		7.4			7.5	13.46	5.38	14.49	Clear...	Poor ...	1.5				Calm.

RANGE, 700 YARDS.

Number of piece.	Caliber.	Date of firing.	Number of previous rounds fired.	Number of shots fired.	Number of shots in target.	Elevation.	Vertical deviation.		Horizontal deviation.		Mean vertical deviation.	Mean horizontal deviation.	Mean absolute deviation or radius of circle of shots.	Weather.	Light.	Wind.		Component of wind normal to range.	Component of wind parallel to range.	Remarks.
							Above.	Below.	Right.	Left.						Miles per hour.	Direction.			
		1897.				° ′ ″	″	″	″	″	″	″	″				O'clock.			
36026	.30	May 21	425	18	10	47 7	2.21	......	......	106.30	8.25	12.30	14.96	Cloudy.	Poor ...	12	4.00	10.4	......	
36208	.30	May 21	418	9	9	42 41	4.55	......	......	79.14	8.50	8.20	11.81	Cloudy.	Poor ...	10	4.00	8.66	......	
36026	.30	May 21	456	18	10	47 7	22.10	......	......	38.02	15.16	10.08	18.20	Cloudy.	Poor ...	2	2.00	1.73	......	
36208	.30	May 21	442	10	10	46 10	......	2.22	14.67	......	8.41	9.41	12.62	Cloudy.	Dull ...	6	9.00	6.00	......	
36026	.30	May 27	592	10	10	47 7	11.66	......	16.68	......	7.03	13.33	15.04	Cloudy.	Gray ...	6	7.30	4.25	......	
36208	.30	May 27	550	12	10	46 10	2.48	......	23.19	......	7.76	9.09	11.95	Cloudy.	Gray ...	7.2	7.30	5.09	......	
36026	.30	May 28	602	10	10	47 7	4.98	......	......	27.80	11.50	7.06	13.49	Rainy ..	Poor ...	0	......	......	......	Calm.
36208	.30	May 28	562	10	10	46 10	20.95	......	......	36.96	11.45	12.80	17.17	Rainy ..	Poor ...	2.4	4.00	2.07	......	
36026	.30	July 15	1,563	11	10	Lost.	13.3	......	......	35.80	9.62	8.90	13.10	Clear ..	Fair ...	1	......	......	......	
36208	.30	July 15	1,318	11	10	41 49	17.3	......	......	26.3	15.86	10.06	18.78	Clear ..	Fair ...	1	......	......	......	
47824	.30	June 29	177	13	10	......	......	7.7	2.2	......	12.52	3.86	13.10	Cloudy.	Fair ...	2	9.00	2.0	......	

RANGE, 800 YARDS.

Number of piece.	Caliber.	Date of firing.	Number of previous rounds fired.	Number of shots fired.	Number of shots in target.	Elevation.	Above.	Below.	Right.	Left.	Mean vertical deviation.	Mean horizontal deviation.	Mean absolute deviation or radius of circle of shots.	Weather.	Light.	Miles per hour.	Direction.	Component of wind normal to range.	Component of wind parallel to range.	Remarks.
36208	.30	May 15	280	15	10	56 1	1.31	......	38.76	......	14.21	9.24	16.97	Fair....	Good ..	8	7.30	5.65	......	
36026	.30	May 22	474	14	10	58 17	4.82	......	35.05	......	17.69	13.96	22.54	Fair....	Bright .	4	9.00	4.00	......	
36208	.30	May 22	452	12	10	1 0 54	34.23	......	51.05	......	17.91	17.80	25.24	Fair....	Poor ...	4	8.30	3.86	......	
36026	.30	May 24	521	12	10	58 17	2.13	......	......	62.22	14.60	8.47	16.88	Fair....	Poor ...	5	2.30	4.83	......	
36026	.30	May 26	544	15	10	58 17	1.09	......	36.40	......	10.70	9.96	14.61	Clear...	Good ..	2.5	8.30	2.41	......	
36208	.30	May 26	507	17	10	1 0 54	2.63	......	27.59	......	12.78	9.17	15.66	Clear...	Good ..	2.3	8.30	2.22	......	
36208	.30	July 10	1,279	16	10	56 1	24.10	......	......	20.7	14.12	5.68	15.21	Clear...	Bright .	2	......	......	......	Calm.
36026	.30	July 10	1,524	13	10	58 16	24.6	......	......	29.9	12.08	9.88	16.07	Clear...	Bright .	0	......	......	......	Calm.
36026	.30	July 15	1,537	15	10	58 16	1.3	......	......	22.0	13.9	14.32	19.95	Cloudy.	Hazy ..	1.7	......	......	......	Calm.
36208	.30	July 15	1,295	12	10	56 1	......	9.2	......	20.3	11.78	21.64	24.63	Cloudy.	Hazy ..	1	......	......	......	Calm.
36026	.30	July 15	1,552	11	10	56 41	2.1	......	......	33.5	20.52	7.58	21.87	Clear...	Bright .	1.5	3.00	1.5	......	
36208	.30	July 15	1,307	11	10	56 2	7.8	......	......	43.0	9.64	13.84	16.86	Clear...	Bright .	1.5	......	......	......	Variable.
47824	.30	July 1	190	12	10	......	......	3.1	......	15.0	18.16	12.94	22.29	Clear...	Bright .	0	......	......	......	Calm.
47824	.30	July 15	350	11	10	......	......	10.9	......	25.7	23.28	9.42	25.1	Cloudy.	Good ..	8	4.00	2.59	......	

RANGE, 900 YARDS.

						°	'	"	"	"	"	"	"	"	"							
		1897.																	O'clock.			
36026	.30	May 24	488	19	10	1	10	16	....	7.03	....	152.84	9.07	8.42	12.37	Fair ...	Good ..	10	2.30	9.66	....	
36208	.30	May 24	464	13	10	1	19	12	10.07	....	....	160.55	16.23	9.44	18.75	Fair ...	Good ..	12	3.00	12.0	....	
36026	.30	May 27	559	18	10	1	18	04	3.43	....	56.26	....	27.01	6.98	27.88	Cloudy.	Gray ..	3.6	8.00	3.11	....	
36208	.30	May 27	524	14	10	1	16	01	3.45	....	66.37	....	14.27	14.81	20.56	Cloudy.	Gray ..	6	8.30	5.79	....	
36026	.30	May 28	612	13	10	1	16	57	19.10	....	....	63.00	18.80	12.8	22.74	Cloudy.	Gray ..	5	3.30	4.83	....	
36208	.30	May 28	572	15	10	1	14	28	31.20	....	....	38.10	18.44	12.14	22.07	Fair ...	Good ..	4.4	5.00	2.2	....	
36026	.30	June 3	645	10	10	1	14	32	5.09	....	....	78.98	10.48	8.64	13.58	Cloudy.	Poor...	5	3.00	5	0.00	
36208	.30	June 3	686	10	10	1	16	01	4.04	....	....	65.55	12.86	15.17	19.90	Cloudy.	Poor...	4	3.00	4	0.00	
36026	.30	June 10	933	11	10	1	18	04	42.50	....	46.2	....	16.84	13.48	21.57	Cloudy.	Poor...	4	8.00	3.46	....	
36208	.30	June 10	836	13	10	1	10	59	4.4	....	35.2	....	15.52	9.26	18.07	Cloudy.	Poor...	4.8	8.00	4.15	....	
36026	.30	June 11	944	11	10	1	18	04	36.5	....	....	18.7	19.4	7.2	20.7	Cloudy.	Bad....	0	....	....	....	Calm.
36208	.30	June 11	849	11	10	1	10	59	....	33.80	....	21.4	16.4	12.58	20.66	Cloudy.	Bad....	0	....	....	....	Calm.

RANGE, 1,000 YARDS.

36208	.30	May 15	295	15	10	1	26	17	11.80	....	37.20	....	26.06	49.00	....	....	....	6	....	....	....	Variable.
36026	.30	May 24	507	14	10	1	27	05	14.54	....	....	165.59	11.84	10.05	15.47	Fair....	Good ..	10	2.30	9.65	....	
36208	.30	May 24	477	13	10	1	26	46	2.71	....	....	175.41	8.60	10.69	13.72	Fair....	Good ..	10	2.30	9.65	....	
36026	.30	May 27	577	15	10	1	31	46	....	10.48	105.70	....	13.81	18.78	23.30	Cloudy.	Gray ..	5.5	8.00	4.76	....	
36208	.30	May 27	538	12	10	1	44	32	22.31	....	109.90	....	13.89	16.66	21.65	Cloudy.	Gray ..	4.6	8.30	4.44	....	
36026	.30	May 28	625	14	10	1	27	05	7.49	....	12.91	....	14.15	9.09	16.81	Cloudy.	Gray ..	3	7.00	1.50	....	
36208	.30	May 28	587	12	10	1	26	26	17.31	....	21.44	....	12.94	4.43	13.69	Cloudy.	Gray ..	4	7.30	2.82	....	
36026	.30	June 3	655	11	10	1	28	43	18.94	....	....	82.67	15.92	9.15	18.36	Cloudy.	Gray ..	3.5	3.00	3.5	0.00	
36208	.30	June 3	696	11	10	1	27	30	8.17	....	....	87.67	18.08	13.67	22.66	Cloudy.	Poor...	3.5	3.00	3.5	0.00	
36026	.30	June 11	955	12	10	1	28	43	2.49	....	1.9	....	24.33	16.78	29.55	Cloudy.	Bad....	1	11.00	.5	....	
36208	.30	June 11	860	11	10	1	26	39	....	16.38	....	4.4	18.2	16.52	24.58	Cloudy.	Bad....	1	11.00	.5	....	
36026	.30	June 11	979	12	10	1	25	39	....	4.36	....	66.6	19.8	9.72	22.05	Fair....	Good ..	1	....	....	....	
36208	.30	June 11	883	13	10	1	26	39	18.30	....	....	63.0	29.52	18.42	34.79	Fair....	Good ..	1	....	....	....	
36026	.30	June 17	1,309	13	10	1	24	20	....	2.7	....	64.4	18.0	9.56	20.38	Cloudy.	Good ..	2.5	3.00	2.5	....	
36208	.30	June 17	1,124	12	10	1	26	17	7.0	....	....	75.7	31.62	9.30	32.95	Cloudy.	Good ..	3	3.00	3.0	....	
36026	.30	July 31	1,622	12	10	1	27	5	13.13	....	....	13.14	20.37	17.47	26.83	Fair....	Poor...	2	7.00	1.0	....	
36026	.30	Aug. 2	1,634	13	6	1	27	5	....	2.75	....	16.65	22.8	9.7	24.78	Fair....	Poor...	1.8	8.00	1.6	....	
36208	.30	Aug. 2	1,407	15	10	1	26	46	23.4	....	10.6	....	14.08	11.6	18.24	Fair....	Poor...	2	9.00	2.0	....	
36208	.30	Aug. 5	1,422	13	10	1	26	46	13.5	....	....	27.1	18.28	10.14	20.90	Fair....	Poor...	0	....	....	....	Calm.
36026	.30	Aug. 9	1,667	14	10	1	27	5	14.4	....	....	23.9	18.18	8.50	20.06	Cloudy.	Gray ..	0	....	....	....	Calm.
36208	.30	Aug. 9	1,450	12	9	1	26	46	18.8	....	....	52.5	7.18	5.6	9.10	Cloudy.	Gray ..	1.5	1.00	.75	....	
47824	.30	June 17	42	14	10	...	...	...	16.7	....	....	57.2	27.14	9.8	28.85	Cloudy.	Gray ..	4	3.30	3.86	....	
47824	.30	July 2	240	11	10	...	...	...	7.8	....	39.9	....	30.08	27.58	40.75	Clear ..	Poor...	2	....	....	....	Variable.
47824	.30	July 2	251	12	10	...	...	...	52.9	....	....	8.2	24.62	21.88	32.93	Clear ..	Poor...	1	....	....	....	Variable.

RANGE, 1,100 YARDS.

Number of piece.	Caliber.	Date of firing.	Number of previous rounds fired.	Number of shots fired.	Number of shots in target.	Elevation.			Vertical deviation. Above.	Vertical deviation. Below.	Horizontal deviation. Right.	Horizontal deviation. Left.	Mean vertical deviation.	Mean horizontal deviation.	Mean absolute deviation or radius of circle of shots.	Weather.	Light.	Wind. Miles per hour.	Wind. Direction.	Component of wind normal to range.	Component of wind parallel to range.	Remarks.
		1897.				°	′	″	″	″	″	″	″	″	″				O'clock.			
36026	.30	May 25	533	11	10	1	42	34	....	9.69	87.15	....	23.56	15.99	28.43	Fair....	Good ..	10	7.30	7.07	....	
36208	.30	May 25	490	17	10	1	55	02	....	16.63	77.00	....	36.45	9.84	37.70	Fair....	Gray...	5.5	7.30	3.88	....	
36026	.30	May 29	539	18	10	1	49	12	20.98	....	....	62.80	13.28	12.84	18.47	Foggy .	Bad....	2.5	3.00	2.5	....	
36208	.30	May 29	599	20	10	1	43	47	9.48	....	....	87.54	19.65	24.90	31.72	Foggy .	Bad....	4	3.00	4.0	....	Very foggy.
36026	.30	June 4	666	11	10	1	42	34	....	8.97	....	132.40	27.71	9.74	29.37	Foggy .	Bad....	6	3.30	5.79	....	
36208	.30	June 4	707	10	10	1	42	40	39.96	....	....	122.40	26.8	12.1	29.4	Foggy .	Bad....	4.3	3.00	4.3	....	
36026	.30	June 11	967	12	10	1	44	00	0.00	0.00	....	47.20	26.92	20.82	34.03	Fair....	Poor...	2.6	4.30	1.84	....	
36208	.30	June 11	871	12	10	1	55	02	25.80	....	....	8.00	31.38	19.30	36.84	Fair....	Poor...	2.6	5.00 to 7.00	....	....	
36026	.30	June 11	991	11	10	1	42	34	16.9	....	....	41.00	17.52	9.42	19.89	Fair....	Good ..	1	9.00	1.00	....	
36026	.30	June 12	1,002	11	10	1	42	34	6.5	....	....	14.6	23.06	11.30	25.69	Rainy..	Bad....	1	....	....	....	Variable from the left.
36208	.30	June 12	901	13	10	1	39	56	....	39.5	....	11.4	15.82	8.82	18.11	Rainy..	Bad....	1	....	....	....	Variable from the left.
47824	.30	July 3	263	13	10	....			....	10.8	....	23.0	20.7	11.18	23.52	Cloudy.	Poor...	0	....	....	....	Calm.

RANGE, 1,200 YARDS.

Number of piece.	Caliber.	Date of firing.	Number of previous rounds fired.	Number of shots fired.	Number of shots in target.	Elevation.			Vertical deviation. Above.	Vertical deviation. Below.	Horizontal deviation. Right.	Horizontal deviation. Left.	Mean vertical deviation.	Mean horizontal deviation.	Mean absolute deviation or radius of circle of shots.	Weather.	Light.	Wind. Miles per hour.	Wind. Direction.	Component of wind normal to range.	Component of wind parallel to range.	Remarks.
36026	.30	May 29	557	12	10	2	3	6	28.87	....	152.56	....	19.65	29.18	35.18	Clondy.	Poor...	7.5	7.30	5.3	....	
36208	.30	June 2	634	13	10	2	6	17	29.71	....	16.83	....	46.85	15.54	49.36	Clear ..	Hazy ..	2	7.00	1.0	....	
36026	.30	June 2	569	16	10	2	5	11	9.87	....	105.84	....	27.08	12.02	31.02	Clear ..	Hazy ..	6	7.30	4.24	....	
36026	.30	June 2	585	15	10	2	9	28	34.03	....	26.00	....	22.93	37.62	44.05	Clear ..	Hazy ..	3	7.00	1.5	....	
36208	.30	June 2	647	11	10	2	7	43	49.47	....	....	17.60	43.82	7.18	43.91	Clear ..	Hazy ..	2.5	4.30	1.76	....	
36026	.30	June 4	677	15	10	2	3	6	32.5	....	....	135.3	28.74	9.80	30.36	Foggy .	Bad....	5	3.00	5.00	....	
36208	.30	June 4	717	17	10	2	1	42	28.1	....	....	91.6	23.58	18.8	30.15	Foggy .	Bad....	3	4.00	....	....	Variable.
36026	.30	June 12	1,013	19	10	1	53	12	....	19.7	21.7	....	38.90	20.0	43.74	Cloudy.	Hazy ..	1	....	....	....	Variable from the left.
36026	.30	June 18	1,322	19	10	1	53	12	....	32.2	43.2	....	26.9	29.76	40.11	Cloudy.	Hazy ..	0	10.00	....	....	
36208	.30	June 18	1,136	12	10	1	57	17	....	4.3	64.1	....	40.04	12.08	41.82	Cloudy.	Hazy ..	1	10.00	....	....	

36026	.30	June 18	1,341	14	10	1	55	21	......	22.2	......	45.4	41.24	20.68	46.13	Clear ..	Poor ...	0	......	......	......	Calm, upper current from 2 o'clock.
36208	.30	June 18	1,148	25	10	1	55	20	18.3	......	34.7	......	31.78	16.22	35.68	Clear ..	Poor ...	0	9.00	......	......	Variable.
36026	.30	June 22	1,413	14	10	2	7	31	......	2.0	......	75.5	35.26	9.69	36.56	Clear ..	Poor ...	Lost.	4.00	......	......	
36208	.30	June 22	1,184	21	10	1	58	9	......	6.8	......	109.9	42.75	25.92	49.99	Clear ..	Poor ...	Lost.	4.00	......	......	
36026	.30	July 10	1,489	19	10	2	3	5	21.7	......	......	3.3	29.38	15.8	33.50	Clear ..	Poor ...	0	10.00	......	......	
36026	.30	July 10	1,508	16	10	2	3	5	50.4	......	......	25.0	24.52	14.32	28.39	Clear ..	Poor ...	0	......	......	......	Calm.
47824	.30	June 18	56	15	10	......			......	24.4	17.3	......	40.9	35.7	54.28	Clear ..	Bright .	0	10.00 to 1.00	......	......	Variable, strong upper current.
47824	.30	June 22	92	18	10	......			......	49.5	......	98.4	26.7	18.58	32.52	Clear ..	Poor ...	Lost.	3.30	......	......	
47824	.30	July 3	276	13	10	......			......	30.7	......	.8	26.26	15.96	30.73	Cloudy.	Poor ...	0	5.00	......	......	
47824	.30	July 8	321	14	10	......			......	9.0	......	130.9	23.36	19.64	30.51	Clear ..	Bright .	8	3.00	8.0	......	

RANGE, 1,300 YARDS.

36026	.30	June 2	600	14	10	2	25	48	20.21	......	......	89.37	35.53	22.72	42.17	Clear ..	Bright .	2.5	4.00	2.16	......	
36026	.30	June 2	614	18	10	2	22	8	17.45	......	......	89.17	24.31	25.27	35.07	Clear ..	Bright .	6	5.00	3.00	......	
36208	.30	June 2	672	14	10	2	22	1	4.05	......	......	82.99	22.46	15.09	27.05	Clear ..	Good...	3.5	5.00	1.75	......	
36026	.30	June 2	632	12	10	2	22	8	28.76	......	......	35.90	36.06	11.58	37.80	Clear ..	Poor ...	1.5	......	......	......	Calm.

RANGE, 1,400 YARDS.

36026	.30	June 4	692	20	10	2	32	34	46.95	......	......	112.4	75.00	17.04	76.90	Foggy .	Bad	3.5	3.60	3.5	......	
36208	.30	June 4	734	20	10	2	31	59	25.14	......	......	128.9	57.72	23.28	62.23	Foggy .	Bad	4	3.30	3.86	......	
36026	.30	June 12	1,032	26	10	2	38	8	11.4	......	......	88.3	52.10	10.96	53.24	Cloudy.	Hazy ..	1	2.00	.87	......	
36208	.30	June 12	927	14	10	2	31	59	27.6	......	......	118.8	51.42	12.9	53.01	Cloudy.	Hazy ..	3	3.00	3.00	......	
36026	.30	June 12	1,058	17	10	2	32	34	11.3	......	182.0	......	41.08	28.72	50.12	Clear ..	Bright .	5	8.00	4.33	......	
36208	.30	June 12	941	17	10	2	31	59	61.4	......	207.4	......	40.12	10.06	41.38	Clear ..	Bright .	5.5	8.00	4.76	......	
36026	.30	June 14	1,075	19	10	2	38	8	......	10.9	68.5	......	50.62	13.32	52.34	Cloudy.	Dark...	0	......	......	......	Variable.
36026	.30	June 19	1,355	15	10	2	44	12	......	20.5	4.20	......	19.78	42.8	47.14	Cloudy.	Dark...	Lost.	9.00	......	......	
36026	.30	June 19	1,370	15	10	2	44	12	33.8	......	6.2	......	61.96	25.3	66.92	Clear ..	Poor ...	Lost.	10.00	......	......	
36208	.30	June 21	1,173	11	10	2	36	33	19.1	......	......	49.5	47.3	45.6	65.71	Clear ..	Poor ...	0	9.00	......	......	Calm.
36026	.30	June 21	1,385	28	10	2	44	12	......	4.4	......	43.1	36.96	24.34	44.25	Clear ..	Poor ...	0	9.00	......	......	Calm.
47824	.30	June 21	71	21	8	......			......	55.2	......	56.5	16.38	9.8	19.09	Clear ..	Poor ...	0	10.00	......	......	Calm.

RANGE, 1,500 YARDS.

36026	.30	June 4	712	24	10	2	53	51	1.23	......	......	176.38	34.47	54.51	64.49	Clear ..	Good...	5	1.30	3.53	......	
36208	.30	June 4	754	18	10	2	53	14	......	7.50	......	83.30	48.24	24.48	54.11	Clear ..	Good...	2	1.30	1.41	......	
36026	.30	June 14	1,094	15	10	3	4	35	......	6.5	163.0	......	39.6	13.3	41.77	Cloudy.	Dark...	2.6	9.00	2.6	......	
36208	.30	June 14	974	16	10	3	5	57	9.3	......	140.3	......	54.86	10.78	55.9	Cloudy.	Dark...	2	9.30	1.93	......	

RANGE, 1,600 YARDS.

Number of piece.	Caliber.	Date of firing.	Number of previous rounds fired.	Number of shots fired.	Number of shots in target.	Elevation.			Vertical deviation. Above.	Vertical deviation. Below.	Horizontal deviation. Right.	Horizontal deviation. Left.	Mean vertical deviation.	Mean horizontal deviation.	Mean absolute deviation or radius of circle of shots.	Weather.	Light.	Wind. Miles per hour.	Wind. Direction.	Component of wind normal to range.	Component of wind parallel to range.	Remarks.
		1897.				°	′	″	″	″	″	″	″	″	″				O'clock.			
36026	.30	June 4	736	28	10	3	16	52	......	33.50	......	105.5	20.2	19.28	27.92	Cloudy.	Good...	2	......	......	......	Variable.
36026	.30	June 5	764	51	10	3	28	3	......	9.90	222.10	......	30.54	13.31	33.31	Cloudy.	Hazy ..	4	10.00	3.46	......	
36208	.30	June 5	797	22	10	3	29	35	77.30	......	264.10	......	56.46	48.76	74.60	Cloudy.	Good...	4	10.00	3.46	......	
36026	.30	June 7	841	36	10	3	35	49	......	36.50	209.8	......	26.00	16.74	30.92	Cloudy.	Poor ...	1.5	9.30	1.44	......	
36026	.30	June 14	1,109	17	10	3	29	10	2.4	......	152.3	......	59.98	23.04	64.25	Clear ..	Bright .	1.6	11.00	.80	......	
36208	.30	June 14	990	13	10	3	28	4	55.0	......	81.49	......	37.92	19.02	42.41	Clear ..	Bright .	1.6	9.00	1.6	......	
36026	.30	June 16	1,231	22	10	3	19	9	......	3.7	270.75	......	34.88	9.8	36.23	Clear ..	Good...	4	9.00	4.0	......	
36026	.30	June 17	1,297	12	10	3	35	49	83.4	......	......	29.40	34.66	11.66	36.56	Clear ..	Good...	0	3.00	......	......	Calm.
36208	.30	June 17	1,106	18	10	3	29	35	5.8	......	......	97.5	50.56	31.46	59.55	Clear ..	Good...	Lost.	3.00	......	......	
36026	.30	Aug. 12	1,692	19	10	3	29	10	10.4	......	......	80.8	62.82	41.9	62.96	Clear ..	Poor ...	3	......	......	......	Lost.
36208	.30	Aug. 12	1,462	13	5	3	29	35	6.4	......	......	135.3	53.3	24.52	58.60	Clear ..	Poor ...	1.5	......	......	......	Lost.
36208	.30	Aug. 18	1,497	15	10	3	29	35	26.4	......	......	24.5	55.74	12.94	57.22	Cloudy.	Dark...	0	......	......	......	Calm.

RANGE, 1,700 YARDS.

Number of piece.	Caliber.	Date of firing.	Number of previous rounds fired.	Number of shots fired.	Number of shots in target.	Elevation.			Vertical deviation. Above.	Vertical deviation. Below.	Horizontal deviation. Right.	Horizontal deviation. Left.	Mean vertical deviation.	Mean horizontal deviation.	Mean absolute deviation or radius of circle of shots.	Weather.	Light.	Wind. Miles per hour.	Wind. Direction.	Component of wind normal to range.	Component of wind parallel to range.	Remarks.
36026	.30	June 5	815	26	10	3	42	47	20.50	......	229.0	......	55.96	60.88	82.69	Cloudy.	Good ..	6	......	......	......	Variable.
36208	.30	June 5	819	17	10	3	44	10	0.00	0.00	286.6	......	44.44	30.38	53.83	Cloudy.	Good ..	4	......	......	......	Variable.

RANGE, 1,800 YARDS.

Number of piece.	Caliber.	Date of firing.	Number of previous rounds fired.	Number of shots fired.	Number of shots in target.	Elevation.			Vertical deviation. Above.	Vertical deviation. Below.	Horizontal deviation. Right.	Horizontal deviation. Left.	Mean vertical deviation.	Mean horizontal deviation.	Mean absolute deviation or radius of circle of shots.	Weather.	Light.	Wind. Miles per hour.	Wind. Direction.	Component of wind normal to range.	Component of wind parallel to range.	Remarks.
36208	.30	June 28	1,232	14	10	4	6	16	18.7	......	......	171.00	48.54	35.84	60.33	Clear ..	Good ..	2.6	......	......	......	Variable from the right.
36026	.30	June 28	1,427	13	10	4	7	25	26.0	......	......	14.1	70.00	30.00	76.12	Clear ..	Good ..	2	......	......	......	Variable from the left.
36026	.30	July 1	1,440	15	10	4	2	17	50.2	......	......	111.8	68.12	36.38	77.22	Clear ..	Good ..	2.4	......	......	......	Variable.
47834	.30	July 1	215	25	10	......			32.6	......	......	41.17	69.4	34.72	77.60	Clear ..	Dark ..	0	......	......	......	Calm.

Table A.—*Firings made with U. S. magazine rifle, caliber .30, in calm, showing the drift unaffected by wind.*

Range.	Aimed with telescopic sight and fired from fixed rest.						Fired from the shoulder with muzzle rest, service sight.	
	No. 15849.				No. 15862.		No. 47835.	
	Date.	Drift (left).	Date.	Drift (left).	Date.	Drift (left).	Date.	Drift (left).
Yards.	1896.	"	1896.	"	1896.	"	1896.	"
100	Oct. 30	1.07	Oct. 31	1.69				
200	Oct. 30	4.11						
300	Oct. 30	*a* 0.84						
400	Oct. 30	1.19	Oct. 31	6.57			Nov. 11	5.62
500								
600	Nov. 3	13.43						
700								
800	Oct. 31	16.20						
900	Oct. 31	28.08	Nov. 3	0.76				
1,000	Oct. 31	12.48	Nov. 3	6.40				
1,100	Nov. 3	13.07						
1,200								
1,300								
1,400								
1,500								
1,600								
1,700								
1,800					June 10	41.65		

Range.	Fired from the shoulder with muzzle rest, service sight.							
	No. 47824.				No. 47827.		No. 36208.	
	Date.	Drift (left).	Date.	Drift (left).	Date.	Drift (left).	Date.	Drift (left).
Yards.	1897.	"	1897.	"	1896.	"	1897.	"
100	June 23	3.8					May 18	3.39
200							May 17	4.47
300							May 17	5.57
400	June 26	12.7	July 6	12.5			July 6	16.7
500	July 16	12.8					June 16	7.88
600							May 21	21.22
700								
800	July 1	15.0					July 10	20.7
900	1896. Nov. 3	6.49			Nov. 3	37.59	June 11	21.4
1,000	Nov. 3	25.24			Nov. 3	53.88	Aug. 5	27.1
1,100	Nov. 3	19.70	July 3	23.0				
1,200								
1,300					Nov. 7	11.93		
1,400	1897. June 21	56.5					June 21	49.5
1,500								
1,600							Aug. 18	24.5
1,700								
1,800	July 1	41.17						

a Right.

TABLE A.—*Firings made with U. S. magazine rifle, caliber .30, in calm, showing the drift unaffected by wind*—Continued.

Range.	Fired from the shoulder with muzzle rest, service sight.							
	No. 36208.		No. 36026.					
	Date.	Drift (left).	Date.	Drift (left).	Date.	Drift (left).	Date.	Drift (left).
Yards.	1897.	"	1897.	"	1897.	"	1897.	"
100			May 18	4.41	July 16	4.3		
200			May 17	3.41				
300			May 17	3.17	May 17	6.19		
400			July 6	17.3				
500			May 17	20.4	June 16	9.7	July 16	20.56
600	June 16	18.30	May 21	18.54				
700			May 28	27.8				
800	July 15	20.3	July 10	29.9	July 15	22.0		
900			June 11	18.7				
1,000			Aug. 9	23.9				
1,100								
1,200			July 10	25.00				
1,300			June 2	35.9				
1,400			June 21	43.1				
1,500								
1,600			June 17	29.4				
1,700								
1,800								

APPENDIX 8.

PROGRESS REPORT ON THE MANUFACTURE OF SMALL-ARMS AMMUNITION AT THE FRANKFORD ARSENAL, PA.

FRANKFORD ARSENAL,
Philadelphia, Pa., August 31, 1897.

SIR: In compliance with your instructions, I have the honor to submit the following report of operations under my supervision in the small-arms department at this arsenal during the fiscal year 1897.

There were manufactured and issued during the fiscal year 1897:

	Manufactured.	Issued.
.30-caliber ball cartridges	6,771,621	5,872,240
.30-caliber blank cartridges	1,058,380	788,000
.38-caliber ball cartridges	2,515,525	1,437,370
.38-caliber blank cartridges	508,180	428,700
.45-caliber ball cartridges	4,509,598	1,082,500
.45-caliber blank cartridges	83,000	378,500
Gallery shells, caliber .30	10,350	16,143
Blank caliber .30 cartridges, proof of gun barrels	30,700	30,600
Small-arms primers	2,000,000	1,584,700
Round balls, .45 caliber	158,000	172,500
Revolver bullets, caliber .45	41,800	50,000

Since the last annual report was rendered no change has been made in the case, primer, bullet, or blank cartridge. The case made from 0.12-inch metal, the primer of gilding metal, with brass anvil and G_{36} composition, consisting of 95 parts fulminate of mercury, 35 parts chlorate of potash, 25 parts glass, and 5 parts mealed powder; the cannelured bullet, and the paper bullet for blank cartridges, continue to give entire satisfaction. The same is to be said of the gallery case now made. The ball cartridge complete, the blank cartridge, and the gallery cases now made were fully described by Lieutenant-Colonel Farley in the last annual report from this arsenal.

MATERIAL.

The cartridge brass (70 copper, 30 zinc) received during the last fiscal year has been of excellent quality, gauging well and working well in the various operations of drawing. For a nonreloading cartridge this metal is very satisfactory.

The cupro-nickeled steel continues to give entire satisfaction. Since the failure of the test of cupro-nickel, a domestic product, as a substitute for cupro-nickeled steel in the bullet jackets, which test was described in the last annual report, no further tests in that direction have been made.

The present cartridge metal (70 copper, 30 zinc) has been mentioned above as very satisfactory metal for a nonreloading cartridge case. Exhaustive experiments at this arsenal, conducted by Lieutenant Dunn, into whose hands the matter was placed by Lieutenant-Colonel Farley, have shown beyond doubt that the brittleness observed in the service case, after having been fired with the service primer, is due to the action of the mercury in the primer on the metal of the case, particularly on the zinc. Efforts to secure a reloading case were at first directed to the use of a case containing the smallest permissible amount of zinc. Gilding metal (93 copper, 7 zinc) was experimented with, but proved too soft and unreliable for use with the high pressures now attained in the .30-caliber rifle.

At the present time efforts are directed toward the modification of the primer. Several different methods of doing this are now under consideration. The first method, suggested by Lieutenant Dunn, is to dispense with the use of fulminate of mercury entirely and replace it by gun cotton or one of the smokeless powders; a second method is one suggested by the chemist, Mr. Williams, and is to substitute for the fulminate of mercury fulminate of copper or of zinc. The method now undergoing test, and which it is hoped will be successful, is to substitute for the $G_{.36}$ primer a primer containing a much smaller amount of fulminate of mercury, the place of the fulminate removed being taken by sulphide of antimony and such flame-producing constituents as sulphur and mealed powder. In connection with a primer containing a reduced amount of fulminate of mercury, the intention is to use a metal for the case containing a less amount of zinc, such as 80 copper, 20 zinc, or possibly 85 copper, 15 zinc.

The result of the experiment so far is to indicate that it may even be possible to retain the present service metal (70 copper, 30 zinc), but in any event the composition (80 copper, 20 zinc) appears to have ample strength and to work well under the operations of drawing.

The preliminary experiment with the primers containing a reduced amount of fulminate of mercury and the cartridge metal containing a reduced amount of zinc will be more fully discussed in a separate report, in which will also be given the programme adopted for the final test of this method of securing a reloading cartridge.

MACHINES.

During the fiscal year ended June 30, 1897, the following machines were built:

	Number.
Heading machines	2
Annealing machine (point)	1
Primer-inserting machines	2
Bullet jacket trimming machines	5
Loading machine	1

The capacity of the small-arms plant at present is as follows:

Ball cartridges, caliber .30, per diem	34,000
Miscellaneous, per diem	16,000
Total	50,000

With some small alterations in the machines the daily product of .30-caliber ball cartridges can be increased to about 45,000, with a reduction to 5,000 per diem of the miscellaneous cartridges manufactured.

POWDERS.

The following is a list of the powders tested at this arsenal since the end of the fiscal year 1896:

SMOKELESS POWDERS FOR .30-CALIBER RIFLE.

Du Pont smokeless	Contract powder
Peyton smokeless	Contract powder
Laflin & Rand W.-A. smokeless	Contract powder
Taylor smokeless	Sample
Rottweil smokeless	Sample
Kolfit smokeless	Sample
Savage smokeless	Sample
Weidig No. 1 smokeless	Sample
Du Pont No. 42 smokeless (NN 11.93–30)	Sample
NN No. 1 } NN No. 2 } made by Laflin & Rand Company, after formula of Captain Stuart (NN 12.0–32)	Sample
Laflin & Rand No. 124, made by Laflin & Rand, after formula of Captain Stuart (NN 12.0–32)	Sample
Laflin & Rand W.-A	Sample
Laflin & Rand W.-A. XXX	Sample
Laflin & Rand W.-A. No. 96 XX	Sample
Laflin & Rand W.-A. No. 126	Sample
Laflin & Rand W.-A. No. 134	Sample
Laflin & Rand W.-A. No. 135	Sample

SMOKELESS POWDERS FOR .45-CALIBER RIFLE.

Du Pont No. 1 smokeless, sporting grain	Sample
Du Pont No. 2 smokeless, sporting grain	Sample
Du Pont No. 5 smokeless, sporting grain	Sample
Du Pont No. 7 smokeless, sporting grain	Sample
Du Pont No. 3 smokeless (NN 11.93–30)	Sample
Du Pont No. 4 smokeless (NNA 11 5–40–20)	Sample
Weidig No. 2 smokeless	Sample
Weidig No. 3 smokeless	Sample
Laflin & Rand W.-A. No. 121	Sample

SMOKELESS POWDER FOR .38-CALIBER REVOLVER.

Du Pont smokeless rifle powder (revolver powder)	Sample
Laflin & Rand W.-A. sporting, No. 1	Sample
Laflin & Rand W.-A. sporting, No. 2	Sample

BLACK POWDER FOR .45-CALIBER SPRINGFIELD RIFLE.

Du Pont black powder	Contract

The test of the Taylor, Rottweil, Kolfit, Savage, and Weidig smokeless powders for the .30-caliber rifle showed that none of them is up to the ballistic standard required by the specifications issued by the Ordnance Department.

The samples of NN powder were fired for the information of the Inspector of Powder, United States Army.

The samples of Laflin & Rand W.-A. powders were fired for the information of the Laflin & Rand Smokeless Powder Company, to assist them in their efforts to reduce the heating effect and the erosion produced by the W.-A. powders.

The samples of revolver smokeless powder fired proved to be inferior in ballistic qualities to the black powder now employed.

The Du Pont and Peyton smokeless powders for the .30-caliber U. S. magazine rifle and the Du Pont black powder for the .45-caliber Springfield rifle continue to give satisfactory results. The Laflin & Rand W.-A.

PLATE III.

Appendix 3, 1897.

smokeless powder, while giving excellent ballistic results, has shown itself unsatisfactory because of its great heating qualities and its erosive action on the gun barrel.

A competitive test of the erosion of the gun barrel produced by firing 5,000 rounds with each of the following powders, viz, W.-A. smokeless, Peyton smokeless, Maxim smokeless, Du Pont smokeless No. 1, and Du Pont smokeless No. 3, beginning June 26, 1896, and continued at intervals until completed, showed the powders to be arranged in the following order as regards the amount of erosion produced, beginning with that powder which produced the most erosion: (1) W.-A. smokeless, (2) Peyton smokeless, (3) Maxim smokeless, (4) Du Pont smokeless No. 3, (5) Du Pont smokeless No. 1. A second test for erosion (5,000 rounds) of the Laflin & Rand W.-A. smokeless powder, conducted in April and May, 1897, showed a considerable improvement in this respect over the W.-A. powder used in the first test, but at the same time the erosion produced was considerably greater than that produced by any of the other powders first tested. The result of a third test for erosion (5,000 rounds) of the W.-A. powder, conducted during the present month (August, 1897) with two samples (Nos. 134 and 135) furnished by the Laflin & Rand Powder Company, is as follows: Sample No. 134 shows a considerable improvement over any W.-A. powder heretofore submitted; sample No. 135 gave even better results than No. 134; but both samples gave results that are still greatly inferior to the standard, as shown by the barrel of rifle No. 21244. (Five thousand rounds of Peyton powder were fired in rifle No. 21244 in the original competitive test begun June 26, 1896.)

The W.-A. powders have given most excellent ballistic results in every respect but that of erosion of the gun barrel. It is gratifying to note their continued improvement in this particular.

Smokeless powder for use in the .45-caliber Springfield rifle.—In obedience to directions contained in O. O. file No. 18756, experiments are in progress to obtain a smokeless powder for use in the .45-caliber Springfield rifle. The progress of these experiments has been delayed by the fact that the manufacturers in the United States have hitherto paid little or no attention to the production of a smokeless powder for use in the .45-caliber rifle, and in consequence have been greatly delayed in furnishing samples for test.

From the limited tests already made, it is thought that there will be little difficulty, except the delay mentioned above, in producing a smokeless powder that will give 1,316 feet per second muzzle velocity to the 500-grain bullet, with a pressure not exceeding that produced by black powder under the same conditions, and with an accuracy at least as great as that shown by the black powder.

It is also probable that a smokeless powder can be produced that will give a muzzle velocity of 1,600 feet per second or higher to the 405-grain bullet with a pressure not exceeding and with an accuracy at least as great as that now produced by the use of a black powder and the 500-grain bullet. The advantages of the use of the 405-grain bullet with a muzzle velocity of 1,600 feet per second or higher are, first, greater flatness of trajectory up to a range of 1,000 yards; second, a greater number of rounds of ammunition to be carried per man. The disadvantage is the necessity for alteration of all the sights now attached to the .45-caliber Springfield rifle. When smokeless powder is used, the recoil with 1,600 feet per second muzzle velocity and 405-grain bullet is practically the same as the recoil with 1,316 feet per second muzzle velocity and 500-grain bullet. Both are much less than the recoil now existing with black powder.

The question of tumbling and the necessity for the employment of a jacketed bullet are as yet undetermined.

Samples of smokeless powder for test with 500-grain and 405-grain bullets are now in course of manufacture by the Du Pont and Laflin & Rand powder companies. Upon their receipt at this arsenal the tests with the .45-caliber Springfield rifle will be continued.

Of the samples of smokeless powders for use in the .45-caliber rifle already tested, the highest ballistic results have been shown by the following: Du Pont No. 3 (NN 11.93–30), Du Pont No. 4 (NNA 11.5–40–20), and Weidig No. 2. Taking as a basis for calculation the following results obtained with the sample of Du Pont smokeless powder No. 4 (NNA 11.5–40–20), viz, charge, 30.5 grains; bullet, unjacketed, 500 grains; muzzle velocity, 1,428 feet per second; pressure, 18,000 pounds per square inch, we find, by application of approved formulæ, that a muzzle velocity of 1,720 feet per second with the 405-grain bullet should be obtained by the use of 34.6 grains of Du Pont No. 4 smokeless powder with a pressure of about 22,000 pounds. The maximum energy of free recoil under these last conditions would be 20.864 foot-pounds, which is less than that (21.016 foot-pounds) now existing in the .45-caliber Springfield rifle with black powder and 500-grain bullet.

NOTE.—Both Du Pont No. 3 and Weidig No. 2 samples would also show by calculation that a muzzle velocity close to 1,700 feet per second can be obtained with a 405-grain bullet and pressure not exceeding 23,000 to 25,000 pounds.

To obtain a muzzle velocity of 1,600 feet per second or higher with the 405-grain bullet it will undoubtedly be necessary to employ a smokeless powder of regular granulation, containing nitroglycerin, similar to the Du Pont No. 3 and No. 4 powders mentioned above. The same class of powder could be used to produce a muzzle velocity of 1,316 feet per second with the 500-grain bullet, but the small charge necessarily employed to effect this is objectionable, as it leaves a large amount of unfilled chamber space, rendering necessary the use of a wad, or some similar device, to hold the powder against the primer and insure regularity of ignition. On this account effort is being made to adapt the sporting powder made by the Du Pont Powder Company to the requirements of the .45-caliber Springfield rifle and 500-grain lead bullet. This powder contains no nitroglycerin and is of irregular granulation. Having a low gravimetric density, a charge giving a muzzle velocity of 1,316 feet per second to the 500-grain bullet entirely fills the chamber space of the cartridge. Experiment with samples of the powder already submitted shows that the modifications required are an increase in regularity of velocity and an increase of gravimetric density. A modification of the primer used with the service .30-caliber powders may also be found necessary. These modifications are believed to be entirely practicable. One great advantage that would follow the adoption of this powder for use in the .45-caliber Springfield rifle is the ability of the Du Pont Company to furnish large quantities of the powder on short notice.

EXPERIMENTS.

DIFFERENCE BETWEEN THE MUZZLE VELOCITY OF THE U. S. MAGAZINE RIFLE AND THE U. S. MAGAZINE CARBINE.

Careful experiment at this arsenal to determine the difference between the muzzle velocity of the U. S. magazine rifle and the U. S. magazine carbine when firing the same ammunition has resulted in the

selection of 80 feet per second as the required difference. The following note is now stamped upon all the paper boxes in which .30-caliber ammunition is issued: "To convert velocity with rifle to velocity with carbine, subtract 80 feet from velocity with rifle."

VELOCITY OF .30-CALIBER RIFLE BULLET AT LONG RANGES.

Owing to the impracticability of measuring the velocity of the .30-caliber bullet at long ranges, due to the difficulty experienced in breaking the current in two targets at a long distance from the muzzle of the gun with the .30-caliber rifle bullet, instructions were received at this arsenal, in Ordnance Office file No. 7746, to perform the following experiment, viz: Determine, by means of wire targets, the velocity of the .30-caliber bullet at the muzzle of the gun and also at about 500 yards from the muzzle. Find the charge to give a muzzle velocity equal to the remaining velocity determined at 500 yards. With this charge determine the new remaining velocity at 500 yards, and adopt this as the remaining velocity of service ammunition at 1,000 yards. Repeat the same experiment for another 500 yards, and so obtain the remaining velocity of service ammunition at 1,500 yards, and in the same way determine the remaining velocity again for 2,000 yards.

The above experiment was carried out to the extent of determining the assimilated remaining velocity at 1,000 yards. At this point the irregular flight of the bullet, due to the low charges necessarily employed and the irregularity of the velocities resulting therefrom, made a continuation of the experiment dangerous to the lives of persons outside the arsenal grounds.

From the records of fourteen rounds, corrected to standard conditions, the remaining velocity at 500 yards was found to be 1,121 feet per second. From the records just mentioned and the records of eleven more rounds fired with reduced charges, and corrected to standard conditions, the remaining velocity at 1,000 yards was found to be 820 feet per second.

In connection with the above instructions were received, in Ordnance Office file No. 7746, to determine by means of paper targets the deflections due to wind and to drift at 500 yards, and by the method of reduced velocities the deflections due to wind and to drift at 1,000, 1,500, and 2,000 yards.

This experiment has been delayed by the necessary alterations and repairs of the apparatus for measuring the direction and velocity of the wind. The old method of measuring the direction of the wind was not considered sufficiently accurate for an experiment of this kind, and it has been known for some time that the peculiar situation of the rifle range at this arsenal, with reference to factories and other buildings in close proximity, causes the air currents affecting the bullet on the rifle range to differ from those affecting the vane and anemometer cups in their position on the hospital.

It was decided to place the wind vane and the anemometer cups on the rifle range within a few feet of the path of the bullet, and at a point where they should record as nearly as possible the average wind affecting the bullet in its flight. A dial with a pointer has been devised to record the direction of the wind, and has been placed so that the actual direction of the wind with reference to the trajectory can be read from the proof house with the telescope at the instant the gun is fired. These changes, necessitating alteration and repairs of the wind apparatus, are nearly completed at this date. When fully completed, the experiment

to determine the deflection of the bullet will be taken up and continued as far as the assimilated range of 1,000 yards, beyond which point, as mentioned above, the experiment becomes dangerous.

.30-CALIBER CARTRIDGES TO GIVE A PRESSURE OF 100,000 POUNDS PER SQUARE INCH.

Since the last annual report was rendered from this arsenal 1,200 caliber .30 ball cartridges, loaded to give a pressure of 100,000 pounds per square inch, have been issued to the commanding officer, Springfield Armory. To obtain this pressure with the limited powder chamber of the service case it was necessary to select a powder which, with a comparatively small charge, would give high but regular pressures, and to compress the powder into the case by means of a drift. Such a powder was found in the new Wetterin smokeless. The charge selected was 49 grains. To get this charge into the case the amount of compression put upon the powder was 1 inch. The result was very satisfactory as to the amount of pressure obtained and its regularity.

DEVELOPMENT OF THE PROOF BALL CARTRIDGE.

Experiments have been made at this arsenal during the past year to develop a satisfactory ball cartridge for the proof of gun barrels which would replace the blank cartridges now in use. For this purpose the pressure gun, chambered to receive the blank cartridge for proof of gun barrels, which had been in use at Springfield Armory, was forwarded to this arsenal. Experiment with this pressure gun soon demonstrated that the only change in form necessary to adapt the blank cartridge case for use in ball cartridges was a slight bottling for a distance of about 0.35 inch from the mouth. The bullet selected was of 220 grains weight; metal, 14 lead, 1 tin. It was given such a taper that it could be cast in the mold and afterwards, by being forced through a die, become cylindrical, with diameter of 0.294 inch for a distance of about three-fourths of an inch from its base.

A drawing of this cartridge was, by direction of the Chief of Ordnance, forwarded to the commanding officer, Springfield Armory. A pressure gun was sent to this arsenal, chambered for the ball cartridge.

One thousand ball cartridges, for proof of gun barrels, were sent to the commanding officer, Springfield Armory, for trial. They have recently been reported as unsatisfactory because of loose fit in the chamber, and because 56 per cent of 500 fired broke opposite the junction of the chamber of the barrel and the chamber ring.

After examination of the returned cases it is believed that the trouble experienced is due to the eccentricity existing between the interior of the chamber of the barrel and the chamber ring, this eccentricity producing a shoulder at the junction of the barrel and chamber ring which sheared through the metal of the case under the pressure of the powder gases. Examination of blank proof cases returned from Springfield Armory show that this trouble is present with them also, but in a less degree. Instead of being sheared completely through, a large number of them show a distinct ring around the metal opposite the junction of the barrel and chamber ring.

Hereafter the ball-cartridge case, if manufactured, will be made in accordance with the gauges furnished from Springfield Armory for ball cartridges, May 14, 1897. The new ball cartridges will therefore fit more closely in the chamber, and should give as good results in respect to freedom from shearing as the blank cartridges heretofore furnished.

None of the proof cases, whether made for ball or blank cartridges, has shown any tendency to shear when fired at this arsenal, in a gun having a continuous and concentric chamber.

Respectfully submitted.

COLDEN L'H. RUGGLES,
First Lieutenant, Ordnance Department, U. S. A.

The COMMANDING OFFICER, FRANKFORD ARSENAL, PA.

FRANKFORD ARSENAL,
Philadelphia, Pa., September 10, 1897.

Respectfully forwarded to the Chief of Ordnance, United States Army.

As regards velocity to be obtained with the caliber .45 rifle, referred to within, pressures obtained by the best-known methods indicate that the velocity can be increased above that obtained with black powders without correspondingly increased pressures and strain on the breech mechanism of the gun. The breech mechanism of the Springfield system can not stand the strain of the bolt system, and great care should be taken to prove that the strain on the breech mechanism of the gun corresponds with what the increased velocities and reduced pressures indicate. If increased velocities appear practicable they should not be adopted until the firing of several thousand rounds shows that the breech mechanism of the gun will stand them.

As regards what is stated within relative to proof ball cartridges, for proving gun barrels, I do not believe it possible to make a ball cartridge that will endure so well in a chamber built up in two sections as in one made continuous.

J. M. WHITTEMORE,
Colonel, Ordnance Department, U. S. A., Commanding.

(10584—Enc. 4)

APPENDIX 9.

REPORT UPON THE UTILITY OF TINNING CARTRIDGE SHELLS AT THE FRANKFORD ARSENAL, PA.

FRANKFORD ARSENAL,
Philadelphia, Pa., April 22, 1897.

SIR: I have the honor to submit the following report on a study of the utility of tinning the brass cartridge cases used in manufacturing .30-caliber cartridges.

I.—THEORY.

The practice of tinning was adopted at this arsenal some years ago[1] for black powder cartridge cases, and the writer has not been able to find in the published records and reports of the Department or elsewhere a detailed statement of the reasons for this adoption.

It is assumed that the object was to protect the metal of cases from the corrosive action resulting from the acids produced by decomposition of black powder during storage.

It is thought that if acids available for action on the case are produced in this way, their action must be considered as complicated by the effects of local electro-chemical action. Of the two metals thus exposed, the cathode will be protected at the expense of the anode, and the amount of chemical action will depend largely upon the surface exposure of the latter. For this reason the actual loss in weight per unit area of surface submerged in a given acid solution should be less for brass than for either zinc or copper, and experiment shows this to be true. A practical application of this is found in the voltaic protection of the copper plates covering ship's bottoms where it is found that a surface of zinc equal to the $\frac{1}{150}$ part of the surface of copper exposed to action of salt water is sufficient to entirely protect the copper.

If, then, a metal which is electro-positive with respect to the metal of the case be used to cover the interior surface, all chemical action will be concentrated on the covering as long as the covering lasts. If the covering be electro-negative with respect to case, the covering will be protected from further corrosion as soon as a portion of the interior surface of case, equal to about $\frac{1}{150}$ of surface of covering, is exposed.

Assuming that brass is a mixture of copper and zinc, we have in the surface of the cartridge case minute surfaces of zinc and copper covered by a very thin coating of tin. In electro-chemical order, tin occupies an intermediate position with respect to zinc and copper. A set of local currents exist, probably, for each of the three pairs of metals, zinc and copper, zinc and tin, and tin and copper respectively. Since galvanic action is stronger for zinc and copper than it is for zinc and tin, it follows that the rate of solution of zinc will be retarded as long as the

[1] Pursuant to letter of the commanding officer, Frankford Arsenal, June 23, 1888, cartridge shells for reloading purposes only were directed to be made of brass and tinned, in lieu of copper shells which were not tinned.

copper surfaces are covered by tin. The tin can not be preserved, however, on account of the local currents between the tin and copper surfaces, the effect of which is to protect the copper at the expense of the tin.

If the above assumptions as to the nature of chemical action are correct, it follows:

(1) That a tin coating does afford a limited protection to a brass case.

(2) If the tin coating is perfect there will be, at first, a simple case of chemical action, the tin being dissolved. The only chance for electrochemical action will be due to presence of steel-jacketed bullet in contact with tin covering giving the pair of metals, tin and iron. Galvanic action will be weak for this pair, but tin will be the electro-positive element, and hence the one to suffer.

(3) As soon as a portion of the brass surface is exposed, action on the zinc begins, but it is comparatively weak, since tin is the electronegative element.

By another set of local currents the previous action on tin is accelerated, since copper takes the place of iron as cathode. As the exposure of brass surface continues, the influence of the tin coating disappears and action on the zinc of case is accelerated as the local currents between zinc and copper appear.

(4) The time during which tin affords a protection will depend upon the nature and extent of decomposition of powder.

II.—EXPERIMENTAL INVESTIGATION.

It is assumed that nitric acid is the acid most likely to be produced by decomposition of powder.

FIRST EXPERIMENT.

Object.—To determine loss of weight per unit area of surface of metals when immersed in a 5 per cent solution of nitric acid.

The following tables show results:

TABLE I.

Metals tested.	Loss per square inch.		Total loss per square inch in 97 hours.
	In 21 hours.	In next 76 hours.	
	Gram.	*Gram.*	*Gram.*
Tin	0.2682	0.4656	0.7338
Copper	.0042	.2020	.2062
Zinc	.1549	.1802	.3351
Cartridge, brass	.0081	.0721	.0802
Cartridge, brass, tinned	.0083	.0740	.0823

REMARKS.

(1) The greater loss of tin as compared with zinc is due to the fact that the zinc oxide formed adheres to metal and retards further action, while the tin oxide falls away from the metal.

(2) The loss of cartridge brass is much less than the loss of either zinc or copper when acted on separately. As previously stated, this was to be expected, and is explained by the facts that local electrochemical action takes place, that the copper is protected at the expense of the zinc, and that the zinc loses but little in weight on account of the small surface exposed. It is also probable that in the decomposition of

the electrolyte a deposition is made on the copper surface which prevents accurate measurement of the true loss of weight in zinc.

(3) As judged by this test, the tinning of brass-cartridge metal resulted in a slight increase of loss of weight.

TABLE II.—*Second experiment on loss of weight per square inch of surface exposed.*

Metals tested.	Loss per square inch.	
	In 5 hours.	In next 24 hours.
	Gram.	*Gram.*
Service case, brass, not tinned	0.0069	0.0507
Service case, tinned	0018	*a* 0003

a Gained. In five hours all the tin was dissolved off the metal, but during the next twenty-four hours stannic oxide was deposited on the case.

THIRD EXPERIMENT.

Object.—To determine electro-chemical order of the metals, copper, brass, tin, and zinc.

By use of a Bradley tangent galvanometer and a 5 per cent solution of nitric acid this order was found to be electro-negative, copper, brass, tin, zinc, electro-positive.

REMARKS.

The position of brass is due to its large percentage of copper. This order explains the complete oxidation of zinc and tin before corrosion of copper begins.

FOURTH EXPERIMENT.

Object.—To investigate the voltaic protection afforded by the above metals to each other.

(*a*) Two brass-cartridge cases, one tinned and the other not tinned, were immersed in 5 per cent nitric acid and connected by wire. In from six to seven hours all the tin coating disappeared and a tinge of blue color appeared in liquid, indicating solution of copper.

(*b*) A tinned brass case and a piece of zinc, electrically connected, were immersed in 5 per cent nitric acid. The tin remained unaffected for forty-eight hours. After seventy-two hours the tin showed slight signs of oxidation. Previous experiments had shown that without the protection afforded by zinc the tin covering would have disappeared in from five to seven hours.

(*c*) A brass case, not tinned, and a piece of tin were connected and immersed in 5 per cent nitric acid for several days. The brass case was not attacked, but a great deal of the tin was converted into stannic oxide, most of which collected at bottom of vessel. Some of it was deposited on the brass case.

(*d*) A tin disk (weight 48.3842 grams, superficial area 7.8126 square inches), and a cartridge-brass disk (weight 57.1166 grams, superficial area 7.8126 square inches), were connected and immersed in 5 per cent nitric acid. In one hundred and twenty hours the tin had lost 0.6098 gram per square inch of surface, and the brass had gained 0.0047 gram per square inch. A slight deposit of stannic oxide on brass disk explains the gain in weight.

(*e*) In a similar way it was demonstrated that tin and zinc will protect copper.

REMARKS.

This set of experiments supports the assumptions made in first section of this report as to nature and order of the chemical actions which result in corrosion of brass cartridge cases tinned.

FIFTH EXPERIMENT.

Object.—To determine whether solutions of the service powders, black, W.-A. and Peyton are capable of producing electro-galvanic action.

The jars and plates of three new gravity cells were used. A layer of powder about 2 inches deep was placed in each jar, after which the jar was filled with distilled water. A Bradley tangent galvanometer, coil No. 1 (resistance supposed to be 150 ohms), gave the following deflections for the cells immediately after assembling:

	Degrees.
Black powder cell	34
W.-A. powder cell	24
Peyton powder cell	18
Cell containing distilled water only	0
Cell containing hydrant water only	4
Ordinary gravity cell in good order	47

The plates were removed from the powder cells and the powder solutions allowed to stand for about one week, after which the deflections were found to be:

	Degrees.
Black powder cell	43
W.-A. powder cell	35
Peyton powder cell	23

All currents decreased rapidly on closed circuit.

The cells were then kept short-circuited for a week, after which the deflections were:

	Degrees.
Black powder cell	10
W.-A. powder cell	20
Peyton powder cell	4

When the jars were filled with powder containing only the normal percentage of moisture, no deflections were discernible.

The powder solutions were very nearly neutral. There was a suspicion of acidity when tested by litmus paper, but it was a suspicion only.

REMARKS.

(1) When electro-galvanic action takes place it will be stronger in black than in smokeless-powder cartridges.

(2) This is corroborated by the samples submitted, which show more corrosion in the .45-caliber than in the .30-caliber cartridges for equal storage.

(3) If corrosion depends upon galvanic action, cartridge cases containing W.-A. powder should be affected more by long storage than those containing Peyton powder.

In the sample cases it will be seen that the 2-year old Leonard powder cases were affected more than the Peyton cases. The oldest W.-A. cases are one year and a half old, and those examined show little, if any, action.

SAMPLE CASES.

A complete exhibit can be made of the corrosive effect of black powder under ordinary conditions of storage, but in the case of smokeless powder only 2-year old cases are available.

Board No. 1, submitted herewith, shows the action of black powder on tinned and untinned brass cases during storage of from one to twenty-seven years.

Board No. 2 shows action of smokeless powders during one and two years' storage.

Board No. 3 shows, for comparison, the action of black and smokeless powders during a period of forty-five days. Extreme conditions were obtained by loading the powder while wet and storing the cartridge in water.

REMARKS.

(1) The progressive action of black powder is shown very clearly by No. 1 board. The tin in contact with black powder lasts for about two years. Very little, if any, is left after four years. The rate of corrosion by black powder decreases after about four years, due, probably, to the protection afforded by the hard, black deposit which adheres closely to metal of case. Boiling for hours in water will not remove this deposit from old cases. A soaking overnight in concentrated ammonia does remove it, and the blue color produced in the ammonia shows the presence of copper salts.

A box of .50-caliber black-powder cartridges, loaded by the Union Metallic Cartridge Company in 1872, were fired. One of the 20 cases ruptured transversely, but this was due, apparently, to original defect in case.

(2) Board No. 2: The discarded Leonard powder shows the greatest erosion. The oldest W.-A. sample is one year and a half old, and the indications are that this powder has the least corrosive action during storage for this time.

When sufficient moisture is absorbed, or when the powder decomposes sufficiently to start galvanic action, it is probable that the corrosive action of this powder will exceed that of the Peyton. The Leonard powder cartridges, which show the greatest corrosion of cases, showed also the greatest falling off in velocity for the two years' storage (1,964 to 1,890 feet per second, while the Peyton cartridges showed practically no loss), thus indicating that corrosion and deterioration of powder go together.

Smokeless powders do not stick to the case as does the black powder. As it is not probable that smokeless-powder cartridges will ever be kept stored in quantity for more than five years, no fear need be entertained of a serious weakening of case by corrosion during storage.

Cases loaded with black powder will last, under normal conditions, for thirty years at least, and, so far as we know at present, cases loaded with smokeless powder should last longer.

CONCLUSION.

(1) Under normal conditions of storage, brass cartridge cases do not need protection against corrosive action of black or smokeless powders. When moisture in excess is present, or when the powder has suffered material decomposition, the protection afforded by tinning the case is too slight to justify, on this ground, the expense involved in tinning.

(2) To insure a neat appearance in finished product, however, the .30-caliber cases must be either tinned or jumbled.

The expense of tinning, floor space not included, is only about 7 cents per 1,000. It would cost nearly, if not quite, as much to jumble them, and tinning gives a neater appearance. It also furnishes a distinctive mark for the Frankford Arsenal product.

RECOMMENDATION.

It is therefore recommended that the tinning of .30-caliber brass cartridge cases be continued.

Very respectfully,

B. W. DUNN,
Lieutenant, Ordnance Department, U. S. A.

The COMMANDING OFFICER, FRANKFORD ARSENAL, PA.

FRANKFORD ARSENAL,
Philadelphia, Pa., April 22, 1897.

Respectfully forwarded to the Chief of Ordnance, United States Army.

I concur in Lieutenant Dunn's recommendation, that the tinning of brass shells be continued.

J. M. WHITTEMORE,
Colonel, Ordnance Department, U. S. A., Commanding.

(18779—Enc. 2)

APPENDIX 10.

TABLES OF FIRE FOR U. S. MAGAZINE RIFLE AND CARBINE, CALIBER .30, PREPARED AT THE FRANKFORD ARSENAL, PA.

PART I.—MEASURED REMAINING VELOCITY AND COEFFICIENT OF REDUCTION.

FRANKFORD ARSENAL,
Philadelphia, Pa., February 20, 1897.

SIR: Pursuant to your verbal directions, I have the honor to submit the following report on the determination of the remaining velocity of the .30-caliber bullet fired from the rifle and from the carbine, respectively, and of the calculation of the value of the coefficient of reduction "c" from the data so obtained.

Considerable difficulty was experienced in obtaining velocities at the range of 1,450 feet, due to the small targets necessarily employed and to the fact that the bullet on striking the wires of the targets near the muzzle was often deflected from its normal path.

The recorded velocities are as follows:

Record of velocities at 50 feet from the muzzle and at 1,450 feet from the muzzle obtained from firings of the U. S. magazine rifle, caliber .30, at Frankford Arsenal.

Date.	Velocity at 50 feet from muzzle.	Velocity at 1,450 feet from muzzle.	Atmospheric conditions.			
			Barometer.	Thermometer.		Humidity.
				Dry.	Wet.	
1897.	*Ft. per sec.*	*Ft. per sec.*	*Inches.*	°	°	*Per cent.*
Jan. 5	1,942	1,129	29.76	44	39	61
5	1,956	1,135.5	29.76	44	39	61
5	1,950	1,148	29.76	44	39	61
6	1,958	1,132	29.95	28	....	60

Record of velocities at 50.4 feet from the muzzle and at 1,450.4 feet from the muzzle obtained from firings of the U. S. magazine carbine, caliber .30, at Frankford Arsenal.

Date.	Velocity at 50.4 feet from muzzle.	Velocity at 1,450.4 feet from muzzle.	Atmospheric conditions.			
			Barometer.	Thermometer.		Humidity.
				Dry.	Wet.	
1897.	*Ft. per sec.*	*Ft. per sec.*	*Inches.*	°	°	*Per cent.*
Jan. 6	1,876	1,103	30	29	....	60
6	1,848	1,066	30	29	....	60
6	1,855	1,044	30	29	....	60
6	1,846	1,061	30	29	....	60
6	1,818	1,058	30	29	....	60

In the computation of the value of the coefficient of reduction "c" the percentage of moisture has been taken as "two-thirds saturation,"

as in Ingalls's Handbook of Ballistics; the actual humidity during the firing was 61 per cent and 60 per cent on January 5 and January 6, 1897. The difference is regarded as inappreciable.

The values of "c" are as follows:

U. S. magazine rifle.

Date.	Value of "c."	Mean variation.
Jan. 5	0.90908	0.01264
5	.91003	.01359
5	.88441	.01203
6	.88225	.01419

Mean value of "c" 0.89644
Mean variation from the mean .... .01311

U. S. magazine carbine.

Date.	Value of "c."	Mean variation.
Jan. 6	0.86381	−0.04968
6	.91205	− .00144
6	.96713	+ .05364
6	.92104	+ .00755
6	.90343	− .01006

Mean value of "c" 0.91349
Mean variation from the mean .... .02447

In connection with the values of "c" just determined, it is well to note that these values are based on a value for the diameter of the bullet in flight equal to 0.30642— inch.

There seems to be a difference of opinion among those who have computed trajectories of the .30-caliber rifle as to whether the diameter of the bore across the lands (0.30 inch) or the diameter of the bore across the grooves (0.308 inch) should be used as the value of d in the expression $\frac{w}{d^2}$. The correct value of d would seem to be the radius of the mean circle of maximum cross section of the bullet in flight. This value of d is found to be equal to 0.30642 inch, as given above.

It is interesting to compare the value of "c," just determined, with the value determined at this arsenal in 1894. In determining the value of "c" in 1894, the value of d in the expression $\frac{w}{d^2}$ was taken as 0.308 inch. The values of the velocity at 50′ and at 1,450 feet taken with the rifle in 1894, together with the resulting value of "c," based upon a value of d=″.308, are given in the following table:

Date.	Velocity at 50 feet from muzzle.	Velocity at 1,450 feet. from muzzle.	Value of "c."
1894.			
June 2	1,982	1,166	0.88563
2	1,986	1,170	
2	1,982	1,180	
Mean	1,983	1.172	

To compare the value of "c," determined in 1894, with the value determined January 5 and 6, 1897, the value of d should be the same.

Computing the value of "c" from the data now obtained and using d=″.308, we find the value of "c" on this basis equal to 0.88725.

Value of "c" determined in 1897, taking d =″.308	0.88725
Value of "c" determined in 1894, taking d =″.308	.88583
Difference	.00142

This difference is so slight as to be negligible, and confirms in a most satisfactory manner the data obtained in 1894 and the trajectories computed with the said data. These trajectories are given on page 98, Report of the Chief of Ordnance for 1894.

It must be said that the value of the ballistic coefficient "C" determined from any record of initial and terminal velocities remains the same, whatever the value of *d* used in its computation when the coefficient of reduction "c" is the one corresponding to the value of *d* used.

Thus assuming $\frac{\delta}{\delta'} = 1$, we have for the value of "C" when d = .30642 and "c" = .89644, "C" = .37345, and for the value of "C" when d = .308 and "c" = .88725, "C" = .37345.

The value of "C," resulting from the experiments in June, 1894, = .3740. The difference between this value and the value of 0.37345 is inappreciable.

It will be observed that the value of "c" for the carbine determined above is greater than that determined for the rifle. The observations were most carefully made, and there is nothing to warrant a discrediting of the results obtained.

The difference in the 500 and 1,000 yards trajectories resulting from the two values of "c" = .89644 and "c" = .91349 is so slight as to be negligible; and all practical purposes will be served by taking "c" = .9 for both the rifle and the carbine at these ranges.[1]

Respectfully submitted.

COLDEN L'H. RUGGLES,
First Lieutenant, Ordnance Department, U. S. A.

The COMMANDING OFFICER, FRANKFORD ARSENAL, PA.

Approved and respectfully forwarded to the Chief of Ordnance, United States Army, in connection with 3d indorsement on letter No. 7746—Enc. 29.

J. P. FARLEY,
Lieutenant-Colonel, Ordnance Department, U. S. A., Commanding.

(7746—Enc. 36)

PART II.—DIFFERENCE IN VELOCITY OF RIFLE AND CARBINE.

FRANKFORD ARSENAL,
Philadelphia, Pa., March 23, 1897.

SIR: Pursuant to your verbal directions I have the honor to submit the following report on the difference in velocity of the same ammunition when fired in the rifle and when fired in the carbine.

The following rounds were fired October 20, 1896, and December 29, 1896 (the velocities given are instrumental velocities at 53 feet from muzzle):

[1] (The difference in the maximum ordinate of two 1,000-yard trajectories, one computed with "c" = .89644 and the other with "c" = .91349, is about ½ foot.) In connection with a value of "c" = .9, the value of d = .30642 should be used.

The 100-foot interval for observed terminal velocities at 1,450 feet range is passed by the bullet in less than 0.094 second of time.

A correction of 0.625 per cent on this time reconciles the difference in carbine and rifle values for "c."

J. P. F.

Comparative test of U. S. magazine rifle and carbine, caliber .30, for velocity.

OCTOBER 20, 1896.

[Service ammunition: Charge, 37.4 grains Peyton powder; bullet, 220 grains N. S.]

Rifle No. 38127, mean of 10 shots	1977.2
Carbine No. 29405, mean of 10 shots	1919.9
Difference, feet per second	57

DECEMBER 29, 1896.

[Ammunition, hand loaded: Charge, 37 grains Peyton powder; bullet, 220 grains N. S.]

Rifle No. 38127, mean of 9 shots	1932
Carbine No. 29405, mean of 9 shots	1866
Difference, feet per second	66

The mean of the differences on the two days is 61.5 feet per second. From this data a difference of 60 feet per second was assumed as that to be expected from the same ammunition when fired in the rifle and in the carbine.

This difference has been marked on the labels of pasteboard packing boxes since about January 2, 1897.

It is known at this arsenal that the velocity of the same ammunition when fired in different rifles will vary by as much as 20 feet per second, even when the rifles tested have not been fired previous to the test.

To eliminate this liability to error in a comparative test of velocity between the rifle and the carbine, an experiment was made as follows:

Sixty cartridges were carefully hand loaded with a charge of powder that gave about 1,964 feet per second in a new rifle, No. 38639.

Twenty-five rounds were then fired with this rifle, using the above ammunition. After firing twenty-five rounds, the barrel of the rifle was sent to the machine shop, where 8 inches were cut off its length (to make the barrel of the same length as the carbine barrel). The barrel was then mounted on the carbine stock and fired 25 more rounds for velocity. The interval of time between the two firings was about one hour. The result was as follows:

March 20, 1897, rifle No. 38639.

[Ammunition, 39.8 grains W.-A. smokeless powder; bullet, 220 grains N. S.]

	Rifle length.	Carbine length.
	Feet per sec.	*Feet per sec.*
Velocity at 53 feet from muzzle.	1,974	1,873
	1,966	1,870
	1,982	1,885
	1,982	1,886
	1,978	1,896
	1,966	1,886
	1,968	1,886
	1,966	1,885
	1,964	1,890
	1,974	1,905
	1,982	1,896
	1,970	1,912
	1,964	1,905
	1,962	1,883
	1,974	1,901
	1,966	1,883
	1,970	1,905
	1,964	1,876
	1,960	1,898
	1,962	1,871
	1,976	1,905
	1,978	1,894
	1,972	1,896
	1,962	1,876
	1,968	1,901
Mean..	*a* 1,970	*b* 1,891

a Thermometer dry, 49°; wet, 48°. Barometer, 29.65 inches.
b Thermometer dry, 51°; wet, 49°. Barometer, 29.68 inches.

The muzzle velocity corresponding to the instrumental velocity of 1,970 feet per second with the barrel of rifle length is 2,010.7 feet per second. The muzzle velocity corresponding to the instrumental velocity of 1,891 feet per second with the barrel of carbine length is 1,930.2 feet per second.

The difference is 80.5 feet per second. For simplicity it is recommended that the fraction be dropped and the difference be accepted as 80 feet per second.

Respectfully submitted.

COLDEN L'H. RUGGLES,
First Lieutenant, Ordnance Department, U. S. A.

The COMMANDING OFFICER, FRANKFORD ARSENAL, PA.

Respectfully forwarded to the Chief of Ordnance, United States Army, in connection with 5th indorsement on letter No. 7746, enclosure 29.

J. PITMAN,
Major, Ordnance Department, U. S. A., Commanding.

(7746—Enc. 46)

OFFICE OF THE CHIEF OF ORDNANCE,
Washington, April 6, 1897.

Respectfully returned to the commanding officer, Frankford Arsenal.

It would appear that the single series of firings reported within, which makes the difference of velocity for the rifle and carbine 80 feet per second, is hardly sufficient to determine so important a factor. Service conditions would be better met if, say, six carbines were fired under similar conditions to reach an average result. It is desired that such firings be made before adopting a standard velocity for the carbine, using ammunition of the standard velocity for the rifle, and if considered advisable making some comparative firings with the rifle at the same time.

It is possible that the powder may affect the result, and the carbine firings should include a series with each of the different makes of powders in service.

CHARLES SHALER,
Acting Chief of Ordnance.

FRANKFORD ARSENAL, PA., *June 9, 1897.*

Respectfully returned to the Chief of Ordnance, United States Army, inclosing velocity results obtained from firing six rifles and six carbines, caliber .30, with three varieties of smokeless powders, viz., Peyton, Du Pont, and W.-A.

The cartridges were hand loaded, charges weighed, and all those for each variety of powder loaded at the same time.

Ten rounds were fired, alternately, from clean rifles and carbines.

The average difference of velocity between the rifle and carbine varied from 88.6 feet per second to 89.8 feet per second, according to the powder used.

Considering each series of ten shots separately, it varied from 71.5 feet per second to 110.4 feet per second with the Peyton powder; comparing single shots, from 15 feet per second to 145 feet per second; thus indicating that it would be difficult to obtain any strictly accurate difference in velocity between the rifle and carbine, as the velocities vary in the individual arms.

In this connection rifle No. 38126, which had been used to test velocity of the daily manufacture of cartridges (Peyton powder) up to June 3, and had been fired about 750 rounds, gave velocities of 1,939 feet per second and 1,913 feet per second as a mean of 10 shots, whereas in rifle No. 43292 (fired 32 rounds), with the same cartridge, a velocity of 1,970.6 feet per second was obtained; all subsequent trials with the former rifle gave these low velocities. On June 8, with 38.3 grains Du Pont No. 11 hand-loaded cartridges, the velocities were (mean of 5 shots) 1,909.2 feet per second, mean variation 8.24 feet per second and 1,964.4 feet per second, mean variation 3.2 feet per second. It would therefore appear to me that the 80 feet per second difference in velocity obtained by Lieutenant Ruggles by cutting off the rifle barrel, thereby eliminating all differences except length of barrel and very slight wear, is as correct a difference between standard velocity of rifle and carbine as can be obtained.

J. M. WHITTEMORE,
Colonel, Ordnance Department, U. S. A., Commanding.

Comparative velocities of rifle and carbine, caliber .50, obtained by firing six rifles and six carbines, April 30 to May 24, 1897.

RIFLE.

[Mean of 10 shots.]

Number.	W.-A. powder, lots 1 to 5, received Sept. 2, 1896. Charge, 39.2 grains; cupro-nickeled steel bullet, 220 grains; G.$_{35}$ primer.			Peyton powder, lot 16, received Jan. 11, 1897. Charge, 37.3 grains; cupro-nickeled steel bullet, 220 grains; G.$_{35}$ primer.			Du Pont powder, lot 11, received Feb. 3, 1897; Charge, 38.6 grains; cupro-nickeled steel bullet, 220 grains; G.$_{35}$ primer.		
	Velocity at 53 feet from muzzle.	Extreme variation.	Mean variation.	Velocity at 53 feet from muzzle.	Extreme variation.	Mean variation.	Velocity at 53 feet from muzzle.	Extreme variation.	Mean variation.
43077	1,968.6	22	7.12	1,962.4	42	10.48	1,952.6	54	12.32
43142	1,975.0	24	7.00	1,968.8	40	10.40	1,963.0	42	7.8
43201	1,980.8	20	6.24	1,972.2	26	7.32	1,984.0	16	5.2
43292	1,991.6	20	5.20	1,981.2	36	9.60	1,984.2	36	11.0
43586	1,971.0	22	6.20	1,966.2	44	12.96	1,966.0	18	4.8
43599	1,993.8	22	5.44	1,977.0	24	9.00	1,976.4	22	4.8
Average	1,980.1	....	6.20	1,971.3	....	9.96	1,971.0	....	7.65

CARBINE.

Number.	Velocity at 53 feet from muzzle.	Extreme variation.	Mean variation.	Velocity at 53 feet from muzzle.	Extreme variation.	Mean variation.	Velocity at 53 feet from muzzle.	Extreme variation.	Mean variation.
35086	1,884.5	55	7.30	1,884.3	23	5.70	1,880.2	43	10.40
35062	1,894.7	27	9.04	1,870.8	54	13.44	1,891.6	87	7.20
35244	1,878.6	47	8.76	1,889.5	50	10.80	1,878.0	22	7.00
35263	1,903.2	40	8.20	1,890.9	56	12.52	1,890.8	30	7.96
35784	1,892.8	71	14.68	1,874.1	37	11.88	1,870.9	43	6.84
35792	1,888.1	28	8.12	1,881.6	46	9.48	1,883.4	30	7.12
Average	1,890.3	....	9.35	1,881.8	....	10.63	1,882.4	....	7.75

VELOCITIES OF RIFLE AND CARBINE, SINGLE SHOTS.

Velocity.	Rifle.			Carbine.		
	W.-A. powder.	Peyton powder.	Du Pont powder.	W.-A. powder.	Peyton powder.	Du Pont powder.
Highest	2,006	1,996	1,998	1,923	1,923	1,910
Lowest	1,960	1,938	1,930	1,845	1,851	1,855
Difference	46	58	68	78	72	55

AVERAGE DIFFERENCE OF VELOCITY IN RIFLE AND CARBINE.

W.-A. powder	89.8
Peyton powder	89.5
Du Pont powder	88.6
Mean	89.3

DIFFERENCE OF VELOCITY IN SETS OF 10 SHOTS.

W.-A. powder:	
Maximum	115.2
Minimum	65.4
Peyton powder:	
Maximum	110.4
Minimum	71.5
Du Pont powder:	
Maximum	113.5
Minimum	61.8

DIFFERENCE OF VELOCITY OF SINGLE SHOTS.

W.-A. powder:	
Maximum	161
Minimum	37
Peyton powder:	
Maximum	145
Minimum	15
Du Pont powder:	
Maximum	143
Minimum	20

(7746—Enc. 54)

PART III.—COMPUTED TABLES OF FIRE FOR U. S. MAGAZINE RIFLE, CALIBER .30.

FRANKFORD ARSENAL,
Philadelphia, Pa., June 1, 1897.

SIR: I have the honor to submit the following memoranda of the trajectory of the U. S. magazine rifle, caliber .30, pursuant to the instructions contained in Ordnance Office file No. 7746:

1. ELEVATION.

Range.	Angle of departure.			Range.	Angle of departure.		
Yards.	°	′	″	*Yards.*	°	′	″
100	0	4	29	1,100	1	53	22
200	0	9	43	1,200	2	12	17
300	0	15	51	1,300	2	32	47
400	0	23	02	1,400	2	55	0
500	0	31	35	1,500	3	19	0
600	0	41	27	1,600	3	44	24
700	0	52	53	1,700	4	12	10
800	1	5	47	1,800	4	41	43
900	1	20	9	1,900	5	14	8
1,000	1	36	1	2,000	5	49	4

5. VELOCITY.

Range.	Remaining velocity.	Range.	Remaining velocity.
Yards.	*Feet per sec.*	*Yards.*	*Feet per sec.*
100	1,783	1,100	792
200	1,590	1,200	755
300	1,418	1,300	721
400	1,265	1,400	688
500	1,138	1,500	657
600	1,044	1,600	628
700	978	1,700	600
800	923	1,800	575
900	874	1,900	550
1,000	831	2,000	527

6. Force of Impact.

Range.	Remaining energy.	Range.	Remaining energy.
Yards.	*Foot-lbs.*	*Yards.*	*Foot-lbs.*
100	1,553.4	1,100	306.4
200	1,235.3	1,200	278.5
300	985.2	1,300	253.7
400	781.9	1,400	231.4
500	632.8	1,500	210.8
600	532.6	1,600	192.9
700	467.4	1,700	175.9
800	416.3	1,800	161.6
900	373.3	1,900	147.8
1,000	337.4	2,000	135.6

8. Pressure.

The pressure per square inch in the chamber of the gun is 38,000 pounds.

9. Recoil.

The maximum energy of free recoil is 10.025 foot-pounds.

10. Time of Flight.

Range.	Time of flight.	Range.	Time of flight.
Yards.	*Seconds.*	*Yards.*	*Seconds.*
100	0.159	1,100	2.957
200	.337	1,200	3.349
300	.537	1,300	3.758
400	.761	1,400	4.186
500	1.012	1,500	4.634
600	1.288	1,600	5.102
700	1.585	1,700	5.603
800	1.901	1,800	6.112
900	2.235	1,900	6.626
1,000	2.587	2,000	7.231

10½. Angle of Fall.

Range.	Angle of fall.			Range.	Angle of fall.		
Yards.	°	′	″	*Yards.*	°	′	″
100	0	4	50	1,100	3	18	55
200	0	11	19	1,200	3	55	38
300	0	19	55	1,300	4	36	21
400	0	31	12	1,400	5	21	28
500	0	45	55	1,500	6	11	29
600	1	4	1	1,600	7	5	38
700	1	25	10	1,700	8	6	10
800	1	49	4	1,800	9	13	5
900	2	15	46	1,900	10	27	20
1,000	2	45	38	2,000	11	49	38

11. Maximum Range.

The maximum range is 4,066 yards, the angle of departure being 44°, and the time of flight 34.6 seconds.

12. Ordinates of Trajectory above Line of Sight—Rifle.

Horizontal distance.	100 yards.	200 yards.	300 yards.	400 yards.	500 yards.	600 yards.	700 yards.	800 yards.	900 yards.	1,000 yards.	1,100 yards.	1,200 yards.	1,300 yards.	1,400 yards.	1,500 yards.	1,600 yards.	1,700 yards.	1,800 yards.	1,900 yards.	2,000 yards.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
100 yards	0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
200 yards	0.46	0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
300 yards	0.99	1.07	0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
400 yards	1.62	2.32	1.88	0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
500 yards	2.36	3.82	4.12	2.98	0	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
600 yards	3.23	5.54	6.70	6.43	4.37	0	......	......	......	......	......	......	......	......	......	......	......	......	......	......
700 yards	4.22	7.53	9.69	10.42	9.30	5.99	0	......	......	......	......	......	......	......	......	......	......	......	......	......
800 yards	5.35	9.79	13.07	14.92	14.92	12.74	7.88	0	......	......	......	......	......	......	......	......	......	......	......	......
900 yards	6.60	12.29	16.83	19.94	21.19	20.26	16.65	10.03	0	......	......	......	......	......	......	......	......	......	......	......
1,000 yards	7.99	15.06	20.99	25.48	28.12	28.57	26.34	21.10	12.46	0	......	......	......	......	......	......	......	......	......	......
1,100 yards	9.51	18.10	25.54	31.54	35.69	37.66	36.94	33.21	26.08	15.14	0	......	......	......	......	......	......	......	......	......
1,200 yards	11.16	21.40	30.49	38.15	43.95	47.56	48.50	46.41	40.93	31.62	18.13	0	......	......	......	......	......	......	......	......
1,300 yards	12.95	24.98	35.87	45.31	52.90	58.31	61.03	60.73	57.03	49.51	37.79	21.45	0	......	......	......	......	......	......	......
1,400 yards	14.89	28.87	41.69	53.08	62.61	69.95	74.61	76.25	74.48	68.89	59.10	44.68	25.15	0	......	......	......	......	......	......
1,500 yards	16.98	33.05	47.96	61.43	73.05	82.47	89.21	92.92	93.23	89.71	82.12	69.52	52.05	29.45	0	......	......	......	......	......
1,600 yards	19.27	37.62	54.82	70.57	84.47	96.17	105.19	111.18	113.76	112.51	107.06	96.96	81.75	60.90	33.83	0	......	......	......	......
1,700 yards	21.73	42.54	62.20	80.42	96.77	110.93	122.40	130.84	135.86	137.05	134.03	126.37	113.58	95.16	70.55	39.07	0	......	......	......
1,800 yards	24.37	47.82	70.11	90.96	109.95	126.74	140.83	151.89	159.52	163.32	162.91	157.85	147.65	131.81	109.78	80.86	44.34	0	......	......
1,900 yards	27.23	53.55	78.70	102.41	124.25	143.89	160.83	174.73	185.20	191.83	194.24	191.99	184.60	171.57	152.32	126.18	92.43	50.84	0	......
2,000 yards	30.17	59.42	87.51	114.16	138.95	161.54	181.45	198.30	211.75	221.38	226.80	227.58	223.22	212.77	197.11	172.54	143.76	105.16	57.51	0

13. Dangerous Spaces, Rifle against Infantry and Cavalry.

Distance on line of sight.	Rising branch of trajectory.		Falling branch of trajectory. In front.		Falling branch of trajectory. In rear.		Maximum continuous dangerous space.		Total.	
	Infantry.	Cavalry.	Infantry.	Cavalry.	Infantry.	Cavalry.	Infantry.	Cavalry.	Infantry.	Cavalry.
	Yards.	*Yards.*	*Yards.*	*Yards.*	*Yards.*	*Yards.*	*Yards.*	*Yards.*	*Yards.*	*Yards.*
100 yards	All.	All.	All.	All.	102.49	190.15	202.49	290.15	202.49	290.15
200 yards	All.	All.	All.	All.	109.78	166.27	309.78	366.27	309.78	366.27
300 yards	All.	All.	All.	All.	92.45	132.45	392.45	432.45	392.45	432.45
400 yards	80.39	All.	137.85	All.	72.74	102.50	210.59	502.50	290.98	502.50
500 yards	44.85	176.63	79.95	154.41	56.76	79.24	136.71	233.65	181.56	410.28
600 yards	31.31	108.24	54.70	87.17	43.60	61.11	98.30	148.28	129.61	256.52
700 yards	23.43	79.07	39.99	60.24	34.38	48.31	74.37	108.55	97.80	187.62
800 yards	18.15	61.45	30.88	45.31	27.50	38.83	58.38	84.14	76.53	145.59
900 yards	14.73	49.50	24.59	35.69	22.54	31.74	47.13	67.43	61.86	116.93
1,000 yards	12.20	40.85	19.92	28.72	18.76	26.49	38.68	55.21	50.88	96.06
1,100 yards	10.28	34.34	16.58	23.75	15.77	22.22	32.35	45.97	42.63	80.31
1,200 yards	8.78	29.28	13.84	19.79	13.49	18.99	27.83	38.78	36.11	68.06
1,300 yards	7.58	25.26	11.84	16.83	11.47	16.25	23.31	33.08	30.89	58.34
1,400 yards	6.60	22.00	10.11	14.43	9.94	13.97	20.05	28.40	26.65	50.40
1,500 yards	5.80	19.30	8.77	12.50	8.41	12.07	17.18	24.57	22.98	43.87
1,600 yards	5.13	17.09	7.67	10.88	7.38	10.58	15.05	21.46	20.18	38.55
1,700 yards	4.56	15.20	6.71	9.51	6.50	9.30	13.21	18.81	17.77	34.01
1,800 yards	4.08	13.59	5.90	8.34	5.75	8.19	11.65	16.53	15.73	30.12
1,900 yards	3.65	12.17	5.19	7.34	5.11	7.23	10.30	14.57	13.95	26.74
2,000 yards	3.28	10.94	4.58	6.47	4.56	6.39	9.14	12.86	12.42	23.80

In computing the dangerous space against cavalry, the gun was assumed to be aimed at the middle of the object, i. e., at a height 48 inches above the ground.

Although the pamphlet description of the Springfield rifle and carbine states that the gun is assumed to be aimed at a point 34 inches above the ground in determining dangerous spaces against both infantry and cavalry, it is thought that such statement is an oversight and that the gun is really assumed to be aimed at the middle of the object. If the gun were aimed at a point 34 inches above the ground in both cases, the dangerous spaces in rear should be the same for cavalry as for infantry.

It was not noticed until the date of writing this report that the Chief of Ordnance, in an indorsement on Ordnance Office file No. 7746, enclosure 47, called attention to the discrepancy in this respect between the Springfield pamphlet and the small arms firing regulations, Blunt, 1889.

The computation of the data corresponding to the above for the U. S. magazine carbine has progressed to a considerable extent, but is now suspended pending an official designation of the muzzle velocity to be accepted for the carbine.

Respectfully submitted.

COLDEN L'H. RUGGLES,
First Lieutenant, Ordnance Department, U. S. A.

The COMMANDING OFFICER, FRANKFORD ARSENAL, PA.

FRANKFORD ARSENAL,
Philadelphia, Pa., June 3, 1897.

Respectfully forwarded to the Chief of Ordnance, United States Army.

J. M. WHITTEMORE,
Colonel, Ordnance Department, U. S. A., Commanding.

(7746—Enc. 53)

PART IV.—COMPUTED TABLES OF FIRE FOR U. S. MAGAZINE CARBINE, CALIBER .30.

FRANKFORD ARSENAL,
Philadelphia, Pa., August 10, 1897.

SIR: I have the honor to submit the following memoranda of the trajectory of the U. S. magazine carbine, caliber .30, in accordance with the directions of Ordnance Office, file No. 7746:

1. ELEVATIONS.

Range.	Angle of departure.	Range.	Angle of departure.
Yards.	° ′ ″	*Yards.*	° ′ ″
100	0 4 52	1,100	2 0 41
200	0 10 33	1,200	2 20 25
300	0 17 13	1,300	2 41 47
400	0 25 2	1,400	3 4 53
500	0 34 14	1,500	3 29 50
600	0 44 55	1,600	3 56 9
700	0 57 07	1,700	4 25 0
800	1 10 47	1,800	4 55 58
900	1 25 58	1,900	5 29 34
1,000	1 42 34	2,000	6 5 30

NOTE.—The muzzle velocity of the U. S. magazine carbine is 1,920 feet per second.

5. VELOCITY.

Range.	Velocity.	Range.	Velocity.
Yards.	*Feet per sec.*	*Yards.*	*Feet per sec.*
100	1,712	1,100	778
200	1,527	1,200	743
300	1,361	1,300	709
400	1,217	1,400	676
500	1,100	1,500	646
600	1,018	1,600	618
700	958	1,700	591
800	905	1,800	565
900	859	1,900	541
1,000	816	2,000	519

6. FORCE OF IMPACT.

Range.	Remaining energy.	Range.	Remaining energy.
Yards.	*Foot-lbs*	*Yards.*	*Foot-lbs.*
100	1,432.1	1,100	296.1
200	1,139.5	1,200	269.6
300	905.4	1,300	245.4
400	723.5	1,400	223.6
500	591.5	1,500	203.8
600	506.6	1,600	186.6
700	448.4	1,700	170.6
800	400.4	1,800	156.1
900	360.1	1,900	143.1
1,000	325.6	2,000	131.4

8. PRESSURE.

Thirty-eight thousand pounds per square inch.

9 RECOIL.

Maximum energy of free recoil is 11.827 foot-pounds.

10. Time of Flight.

Range.	Time of flight.	Range.	Time of flight.
Yards.	*Seconds.*	*Yards.*	*Seconds.*
100	.165	1,100	3.041
200	.351	1,200	3.436
300	.560	1,300	3.853
400	.793	1,400	4.289
500	1.053	1,500	4.747
600	1.337	1,600	5.221
700	1.641	1,700	5.724
800	1.963	1,800	6.251
900	2.303	1,900	6.807
1,000	2.662	2,000	7.388

10½ Angle of Fall.

Range.	Angle of fall.	Range.	Angle of fall.
Yards.	° ′ ″	*Yards.*	° ′ ″
100	0 05 15	1,100	3 27 46
200	0 12 17	1,200	4 05 33
300	0 21 38	1,300	4 47 35
400	0 33 55	1,400	5 34 09
500	0 49 37	1,500	6 25 33
600	1 08 41	1,600	7 21 34
700	1 30 33	1,700	8 24 24
800	1 55 12	1,800	9 33 43
900	2 22 48	1,900	10 50 31
1,000	2 53 39	2,000	12 14 47

11. Maximum Range.

The maximum range of the U. S. magazine carbine is 4,016 yards. The corresponding angle of departure is 44°, and the time of flight 34.3 seconds.

12. ORDINATES OF THE TRAJECTORY ABOVE THE LINE OF SIGHT—CARBINE.

Range.	100 yards.	200 yards.	300 yards.	400 yards.	500 yards.	600 yards.	700 yards.	800 yards.	900 yards.	1,000 yards.	1,100 yards.	1,200 yards.	1,300 yards.	1,400 yards.	1,500 yards.	1,600 yards.	1,700 yards.	1,800 yards.	1,900 yards.	2,000 yards.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
100 yards	0																			
200 yards	0.50	0																		
300 yards	1.08	1.16	0																	
400 yards	1.76	2.53	2.05	0																
500 yards	2.56	4.13	4.46	3.21	0															
600 yards	3.50	6.00	7.25	6.94	4.66	0														
700 yards	4.56	8.13	10.45	11.20	9.98	6.39	0													
800 yards	5.75	10.51	14.02	15.97	15.94	13.54	8.34	0												
900 yards	7.08	13.16	18.00	21.27	22.57	21.49	17.62	10.60	0											
1,000 yards	8.53	16.06	22.35	27.07	29.82	30.19	27.76	22.19	13.03	0										
1,100 yards	10.11	19.23	27.09	33.40	37.72	39.67	38.82	34.83	27.25	15.79	0									
1,200 yards	11.84	22.68	32.27	40.29	46.34	50.01	50.88	48.60	42.74	32.99	18.92	0								
1,300 yards	13.70	26.41	37.87	47.76	55.67	61.20	63.93	63.52	59.51	51.62	39.40	22.31	0							
1,400 yards	15.72	30.45	43.93	55.84	65.77	73.32	78.06	79.66	77.66	71.78	61.56	46.50	26.16	0						
1,500 yards	17.91	34.82	50.48	64.57	76.69	86.41	93.33	97.11	97.28	93.57	85.47	72.65	54.38	30.42	0					
1,600 yards	20.21	39.42	57.38	73.76	88.15	100.15	109.33	115.35	117.76	116.27	110.42	99.70	83.68	61.81	33.52	0				
1,700 yards	22.74	44.48	64.96	83.87	100.78	115.29	126.98	135.51	140.41	141.41	138.04	129.79	116.23	96.81	70.95	39.86	0			
1,800 yards	25.46	49.92	73.12	94.73	114.35	131.56	145.95	157.16	164.75	168.42	167.71	162.12	151.20	134.41	111.16	82.67	45.39	0		
1,900 yards	28.42	55.83	81.98	106.53	129.09	149.24	166.55	180.69	191.19	197.75	199.94	197.22	189.17	175.23	154.82	129.15	64.67	52.05	0	
2,000 yards	31.58	62.16	91.46	119.18	144.89	168.18	188.63	205.89	219.49	229.18	234.44	231.81	229.82	218.93	201.52	178.87	147.37	107.72	58.60	0

Dangerous Spaces, Carbine against Infantry and Cavalry.

[Calculated under the assumption that the gun when fired is 56 inches from the ground, that the height of a man is 68 inches, that the head of a man on horseback is 8 feet above the ground, and that the gun is aimed at the middle point of the target.]

Distance on line of sight.	Rising branch of trajectory.		Falling branch of trajectory. In front.		Falling branch of trajectory. In rear.		Maximum continuous dangerous space.		Total.	
	Infantry.	Cavalry.	Infantry.	Cavalry.	Infantry.	Cavalry.	Infantry.	Cavalry.	Infantry.	Cavalry.
	Yards.	*Yards.*	*Yards.*	*Yards.*	*Yards.*	*Yards.*	*Yards.*	*Yards.*	*Yards.*	*Yards.*
100 yards	All.	All.	All.	All.	100.25	183.63	200.25	283.63	200.25	283.63
200 yards	All.	All.	All.	All.	105.11	158.79	305.11	358.79	305.11	358.79
300 yards	All.	All.	All.	All.	87.83	125.53	387.83	425.53	387.83	425.53
400 yards	69.62	All.	121.72	All.	68.79	96.80	190.51	496.80	260.13	496.80
500 yards	40.74	153.27	73.18	133.24	53.06	74.39	126.24	207.63	166.98	360.90
600 yards	28.95	98.26	50.23	79.07	41.43	57.98	91.66	137.05	120.61	235.31
700 yards	21.57	72.69	37.09	55.82	32.83	46.00	69.92	101.82	91.49	174.51
800 yards	17.01	56.87	28.80	42.33	26.51	37.22	55.81	79.55	72.32	136.42
900 yards	13.81	46.03	22.76	33.22	22.05	30.80	44.81	64.02	58.62	110.05
1,000 yards	11.47	38.17	18.76	27.12	18.23	25.54	36.99	52.66	48.46	90.83
1,100 yards	9.68	32.22	15.69	22.60	15.28	21.39	30.97	43.99	40.65	76.21
1,200 yards	8.28	27.56	13.25	18.96	12.94	18.22	26.19	37.18	34.47	64.74
1,300 yards	7.17	23.84	11.32	16.13	11.09	15.63	22.41	31.76	29.58	55.60
1,400 yards	6.26	20.82	9.75	13.89	9.54	13.42	19.29	27.31	25.55	48.13
1,500 yards	5.50	18.30	8.46	12.01	8.27	11.63	16.73	23.64	22.23	41.94
1,600 yards	4.87	16.24	7.37	10.46	7.21	10.16	14.58	20.62	19.45	36.86
1,700 yards	4.34	14.46	6.44	9.13	6.31	8.90	12.75	18.03	17.09	32.49
1,800 yards	3.88	12.93	5.64	7.99	5.55	7.83	11.19	15.82	15.07	28.75
1,900 yards	3.48	11.60	4.95	7.02	4.90	6.90	9.85	13.92	13.33	25.52
2,000 yards	3.13	10.44	4.35	6.18	4.34	6.10	8.69	12.28	11.82	22.72

Respectfully submitted.

COLDEN L'H. RUGGLES,
First Lieutenant, Ordnance Department, U. S. A.

The COMMANDING OFFICER, FRANKFORD ARSENAL, PA.

FRANKFORD ARSENAL, PA., *August 17, 1897.*

Respectfully forwarded to the Chief of Ordnance, United States Army, in connection with similar ballistic data for U. S. magazine rifle, computed by Lieut. Colden L'H. Ruggles, Ordnance Department, embraced in his report of June 1, 1897, forwarded June 3, 1897.

J. M. WHITTEMORE,
Colonel, Ordnance Department, U. S. A., Commanding.

(7746—Enc. 57)

APPENDIX 11.

EFFECT OF TEMPERATURE ON VELOCITY OF .30 CALIBER AMMUNITION—EXPERIMENTS AT THE FRANKFORD ARSENAL, PA.

(2 plates.)

FRANKFORD ARSENAL,
Philadelphia, Pa., January 9, 1897.

SIR: I have the honor to submit a report of work performed pursuant to the following order:

[Fabrication Order No. 296-A.]

FRANKFORD ARSENAL,
Philadelphia, Pa., October 10, 1896.

Lieut. B. W. Dunn, Ordnance Department, is hereby directed to take the necessary steps, at the earliest date, for testing caliber .30 ammunition by exposure to temperatures at each 10° from 0° to 110° F. and determining velocities, as indicated in Department letter No. 12185—Enc. 30.

J. P. FARLEY,
Lieutenant-Colonel, Ordnance Department, U. S. A., Commanding.

The object of tests was to determine the variations in initial velocity due to changes in temperature of the cartridge. By the correspondence referred to in above order it was required (1) that 240 standard cartridges should be brought to a temperature of 0° F., by exposure for twenty-four hours in a chamber having that temperature, and should then have their temperature raised by similar exposures and by equal increments of 10° F. to 110° F. or higher, 20 cartridges being withdrawn and fired for velocity at the ends of the successive twenty-four hours' exposures; (2) that the test should be repeated with another lot of 240 cartridges, starting at a temperature of 110° F. or higher, and decreasing by similar exposures and by 10° decrements to 0° F., firing for velocity as before.

The cartridges used were hand loaded with Du Pont Peyton powder and with charges intended to give a standard velocity of about 1,968 feet per second, as requested by the commanding officer of the armory. The actual velocity obtained, as determined by firing 20 untreated cartridges from each lot, was slightly less than this; but the change in initial velocity of any lot of cartridges due to temperature of cartridges when fired can be obtained by applying to the standard velocity of such lot the corrections hereinafter given.

An examination of detailed data shows some inconsistencies, such, for instance, as one or two cartridges in a group of 20 showing velocities differing largely from the mean of that group. It is thought that this is probably due to inaccuracies in weighing out the charges; and if the experiments were to be repeated it would be well to have the charge weighed in the chemical laboratory and on the standard scales of the arsenal.

DESCRIPTION OF HEATING AND REFRIGERATING APPARATUS.

This apparatus was designed and constructed by Mr. W. Cooke, refrigerating engineer. It was set up at Frankford Arsenal, experimented with, altered in minor details, and finally made to work with perfect satisfaction. Mr. Cooke was present during the time consumed in adjustment and suggested most of the changes.

The difficulties met were due, principally, to the fact that the apparatus was required to cross the critical temperature—that of the room. The ordinary ovens in chemical laboratories would have given the constant temperatures desired, starting at from 10 to 15° above atmospheric temperature, and running up to and beyond the limit of 110° F. fixed by conditions imposed for this experiment.

In the same way an apparatus giving temperatures around and below the freezing point could have been easily obtained. In addition to having to cross atmospheric temperature it was anticipated that the other condition—that for a period of twenty-four hours the temperature of cartridge chamber had to be kept within 3° of the required value—would be a difficult one to meet in an automatic apparatus.

The apparatus (Pl. I—Enc. 38) furnishes a cartridge chamber, C, figs. 1 and 5, well protected from radiation by mineral-wool packing, and means for introducing into this chamber at will or automatically either hot or cold air. The hot air is furnished by a gas heater, figs. 2 and 5, and its admission to chamber C is controlled by a damper V, operated by hand or by the electric motor, fig. 2, which is in electrical connection with the thermostat, fig. 1.

Cold air is produced in upper chamber, fig. 1, by means of the refrigerating coil, to which liquefied gas may be supplied, as shown in fig. 4.

Anhydrous ammonia was used in these experiments; but if it were desired to maintain a lower temperature than 0° F., carbonic acid would be preferable.

The admission of cold air to cartridge chamber is controlled by damper V′, operated similarly to damper V. The temperature of cartridge chamber is given by a thermometer T, figs. 1, 3, and 5, read from the outside.

The thermostat for controlling temperature of cartridge chamber is a high-grade instrument, constructed in the usual way. The blade, formed of two sheets of steel and aluminum, respectively, is rigidly attached to the shaft b, figs. 1 and 2.

The pointer p is rigidly attached to same shaft and controlled by antagonistic screws a a′. By means of pointer and scale S, fig. 2, the thermostat may be set for any temperature. The lower end of blade is embraced by two adjustable contact points, and the opening or closing of damper V or V′, through agency of the electric motor, depends upon which point is in contact with blade. It was found that a variation of 1° F. from its setting, and frequently a less variation, caused the blade to change contacts, and thereby to operate damper.

For accurate working and for economical use of liquid gas, the temperature in upper or cold chamber should be kept about 10° below that required in cartridge chamber. Another thermostat of comparatively low grade is kept in that chamber and arranged to ring an alarm bell when the temperature there passes a certain limit imposed by the "setting" of this thermostat. The setting is effected by a shaft, pointer, and scale, not shown in drawing, but similar to those explained.

While working above atmospheric temperature it was necessary only to operate the damper V, to supply at intervals by hot air the heat lost by radiation. The damper V′ was open; the gas burned constantly in heater, and the valve in ammonia-supply pipe, fig. 2, was closed.

When working below atmospheric temperature, the damper V was kept closed—the gas not being lighted—and the damper V′ was operated to admit cold air at intervals into cartridge chamber to absorb the heat gained by radiation.

When working near atmospheric temperature, the temperature of cold chamber was kept about 10° below the temperature required in cartridge chamber, and the damper V′ left just enough open to permit a slight leakage of cold air into lower chamber. This tended to keep the temperature in cartridge chamber below atmospheric temperature, and, with gas burning, the automatic operation of damper V supplied the heat necessary to counteract this leakage.

The cartridge chamber C is so well protected by mineral-wool packing that changes in its temperature through radiation into the room containing apparatus take place very slowly. When brought to 0° F. and left undisturbed for sixteen hours in a room the temperature of which ranged from 70 to 65° F., the temperature of chamber C rose less than 10° F.

The following data were obtained:

FIRST SERIES OF TESTS.

[Cartridges loaded by hand with 37.5 grains Du Pont smokeless powder, lot No. 1.]

1. Standard velocity at 53 feet from muzzle—untreated cartridges.

Number of shot.	No. 1 instrument.	No. 2 instrument.	Number of shot.	No. 1 instrument.	No. 2 instrument.
1	1,952	1,950	13	1,946	1,942
2	1,982	1,976	14	1,952	1,952
3	1,962	1,960	15	1,956	1,954
4	1,946	1,942	16	1,962	1,958
5	1,954	1,952	17	1,954	1,954
6	1,954	1,948	18	1,946	1,944
7	1,970	1,966	19	1,950	1,948
8	1,966	1,964	20	1,946	1,944
9	1,950	1,946			
10	1,946	1,942	Mean	1,955.7	1,953.2
11	1,958	1,962	Mean of two instruments.		1,954.5
12	1,962	1,960			

Barometer, 30″.37; thermometer, dry, 28°.

2. After exposure for forty-eight hours to a temperature of 0° F., 20 cartridges were withdrawn and fired.

Number of shot.	No. 1 instrument.	Number of shot.	No. 1 instrument.	Number of shot.	No. 1 instrument.
1	1,923	9	1,926	17	1,966
2	1,932	10	1,912	18	1,978
3	1,908	11	1,942	19	1,938
4	1,905	12	1,954	20	1,952
5	1,910	13	1,938		
6	1,907	14	1,934	Mean	1,931.1
7	1,937	15	1,962		
8	1,908	16	1,990		

Barometer, 30″.54; thermometer, dry, 44°, wet, 40°.

3. After exposure for twenty-four hours to a temperature of 10° F.

Number of shot.	No. 1 instrument.	No. 2 instrument.	Number of shot.	No. 1 instrument.	No. 2 instrument.
1	1,980	1,980	13	1,998	1,994
2	1,996	1,992	14	1,946	1,958
3	1,972	1,970	15	1,952	1,946
4	1,952	1,956	16	1,970	1,972
5	1,974	1,970	17	1,974	1,968
6	1,946	1,940	18	1,960	1,966
7	1,980	1,980	19	1,952	1,948
8	1,964	1,960	20	1,982	1,978
9	1,976	1,970			
10	1,956	1,954	Mean	1,966.7	1,965.1
11	1,970	1,972	Mean of two instruments.		1,965.9
12	1,934	1,928			

Barometer, 30″.26; thermometer, dry, 43°, wet, 43°.

4. After exposure for twenty-four hours to a temperature of 20° F.

Number of shot.	No. 1 instrument.	No. 2 instrument.	Number of shot.	No. 1 instrument.	No. 2 instrument.
1	1,960	1,962	13	1,956	1,956
2	1,966	1,964	14	1,942	1,942
3	1,925	1,921	15	1,923	1,920
4	1,958	1,958	16	1,964	1,966
5	1,962	1,956	17	1,972	1,974
6	1,938	1,940	18	1,938	1,942
7	1,966	1,966	19	1,926	1,923
8	1,942	1,946	20	1,966	1,968
9	1,958	1,954			
10	1,954	1,950	Mean	1,951.9	1,951.4
11	1,966	1,968	Mean of two instruments.		1,951.7
12	1,956	1,952			

Barometer, 30″.49; thermometer, dry, 44°, wet, 40°.

5. After twenty-four hours' exposure to a temperature of 30° F.

Number of shot.	No. 1 instrument.	No. 2 instrument.	Number of shot.	No. 1 instrument.	No. 2 instrument.
1	1,938	1,934	13	1,962	1,956
2	1,994	1,990	14	1,956	1,952
3	1,946	1,942	15	1,930	1,926
4	1,958	1,958	16	1,978	1,974
5	1,960	1,956	17	1,932	1,923
6	1,946	1,946	18	1,936	1,932
7	1,942	1,936	19	1,921	1,918
8	1,928	1,928	20	1,938	1,942
9	1,974	1,970			
10	1,972	1,968	Mean	1,954.3	1,951.3
11	1,992	1,990	Mean of two instruments.		1,952.8
12	1,984	Lost.			

Barometer, 30″.68; thermometer, dry, 48°, wet, 44°.

6. After twenty-four hours' exposure to a temperature of 40° F.

Number of shot.	No. 1 instrument.	No. 2 instrument.	Number of shot.	No. 1 instrument.	No. 2 instrument.
1	1,942	1,940	13	1,887	1,883
2	1,978	1,974	14	1,962	1,962
3	1,956	1,952	15	1,942	1,942
4	1,938	1,938	16	2,002	2,000
5	1,976	1,972	17	1,900	1,898
6	1,936	1,932	18	1,992	1,990
7	Lost.	1,954	19	1,960	1,956
8	1,942	1,942	20	1,936	1,932
9	1,960	1,956			
10	1,930	1,934	Mean	1,948.4	1,946.2
11	1,922	1,918	Mean of two instruments.		1,947.3
12	1,952	1,950			

Barometer, 30″.43; thermometer, dry, 63°, wet, 58°.

7. After twenty-four hours' exposure to a temperature of 50° F.

Number of shot.	No. 1 instrument.	No. 2 instrument.	Number of shot.	No. 1 instrument.	No. 2 instrument.
1	1,954	1,952	13	1,936	1,938
2	1,926	1,926	14	1,982	1,978
3	1,950	1,952	15	1,928	1,932
4	1,962	1,956	16	1,962	1,962
5	1,942	1,944	17	1,962	1,958
6	1,916	1,916	18	Lost.	Lost.
7	1,962	1,958	19	1,952	1,942
8	1,962	1,958	20	1,960	1,958
9	1,952	1,948			
10	1,942	1,936	Mean	1,949.1	1,946.6
11	1,940	1,934	Mean of two instruments.		1,947.8
12	1,942	1,936			

Barometer, 30″.48; thermometer, dry, 58°, wet, 55°.

8. After twenty-four hours' exposure to a temperature of 60° F.

Number of shot.	No. 1 instrument.	No. 2 instrument.	Number of shot.	No. 1 instrument.	No. 2 instrument.
1	1,966	1,962	13	1,978	1,974
2	1,938	1,934	14	1,948	1,942
3	1,966	1,960	15	1,942	1,940
4	1,922	1,920	16	1,952	1,946
5	1,970	1,966	17	1,970	1,966
6	1,916	1,912	18	1,960	1,954
7	1,954	1,950	19	1,920	1,918
8	1,930	1,928	20	1,962	1,958
9	1,946	1,950			
10	1,964	1,962	Mean	1,950.8	1,947.3
11	1,936	1,932	Mean of two instruments.		1,949
12	1,976	1,972			

Barometer, 30″.30; thermometer, dry, 69°, wet, 66°.

9. After twenty-four hours' exposure to a temperature of 70° F.

Number of shot.	No. 1 instrument.	No. 2 instrument.	Number of shot.	No. 1 instrument.	No. 2 instrument.
1	1,978	1,976	13	1,942	1,946
2	2,018	2,018	14	1,956	1,958
3	1,978	1,982	15	2,004	2,008
4	1,974	1,970	16	1,992	1,994
5	1,984	1,988	17	1,948	1,952
6	1,970	1,966	18	1,960	1,962
7	1,978	1,976	19	1,978	1,980
8	1,968	1,966	20	1,936	1,940
9	1,966	1,962			
10	1,976	1,980	Mean	1,973.1	1,974.2
11	1,978	1,982	Mean of two instruments.		1,973.6
12	1,978	1,978			

Barometer, 30″.13; thermometer, dry, 73°, wet, 67°.

10. After twenty-four hours' exposure to a temperature of 80° F.

Number of shot.	No. 1 instrument.	No. 2 instrument.	Number of shot.	No. 1 instrument.	No. 2 instrument.
1	1,986	1,982	13	1,968	1,962
2	1,966	1,962	14	1,976	1,978
3	1,962	1,958	15	1,990	1,986
4	1,958	1,956	16	2,000	2,002
5	1,986	1,982	17	1,926	1,926
6	1,982	1,986	18	1,962	1,960
7	1,974	1,976	19	1,960	1,962
8	1,992	1,988	20	1,974	1,970
9	1,976	1,974			
10	1,964	1,958	Mean	1,973.2	1,971.2
11	1,978	1,976	Mean of two instruments.		1,972.2
12	1,984	1,980			

Barometer, 30″.08; thermometer, dry, 72°, wet, 68°.

11. After twenty-four hours' exposure to a temperature of 90° F.

Number of shot.	No. 1 instrument.	No. 2 instrument.	Number of shot.	No. 1 instrument.	No. 2 instrument.
1	2,014	2,016	13	2,002	2,006
2	1,998	1,994	14	1,982	1,986
3	2,014	2,012	15	1,966	1,970
4	1,970	1,972	16	1,982	1,986
5	1,996	1,992	17	1,992	1,992
6	2,002	2,002	18	1,974	1,976
7	1,974	1,978	19	1,958	1,954
8	1,994	1,998	20	1,966	1,966
9	1,942	1,938			
10	1,998	2,000	Mean	1,982.7	1,983.8
11	1,956	1,960	Mean of two instruments.		1,983.2
12	1,974	1,978			

Barometer, 30″.40; thermometer, dry, 37°, wet, 37°.

12. After twenty-four hours' exposure to a temperature of 100° F.

Number of shot.	No. 1 instrument.	No. 2 instrument.	Number of shot.	No. 1 instrument.	No. 2 instrument.
1	1,996	1,990	13	1,954	1,958
2	1,974	1,970	14	1,992	1,994
3	1,994	1,990	15	1,982	1,980
4	1,992	1,986	16	1,972	1,974
5	1,982	1,978	17	1,986	1,984
6	1,988	1,986	18	2,026	2,024
7	2,002	2,002	19	2,000	2,002
8	1,974	1,970	20	1,998	1,996
9	2,022	2,022			
10	1,998	1,998	Mean	1,991.3	1,989.8
11	1,974	1,974	Mean of two instruments.		1,990.5
12	2,020	2,018			

Barometer, 30″.37; thermometer, dry, 34°; wet, 33°.

13. After twenty-four hours' exposure to a temperature of 110° F.

Number of shot.	No. 1 instrument.	No. 2 instrument.	Number of shot.	No. 1 instrument.	No. 2 instrument.
1	1,978	1,974	13	2,014	2,010
2	2,002	1,998	14	1,992	1,986
3	1,986	1,982	15	1,998	2,004
4	2,002	1,998	16	1,986	1,988
5	2,002	1,996	17	1,974	1,976
6	2,006	2,002	18	1,974	1,974
7	1,998	1,998	19	1,970	1,966
8	2,022	2,022	20	2,002	2,002
9	2,022	2,020			
10	2,010	2,010	Mean	1,997	1,994.9
11	1,992	1,986	Mean of two instruments.		1,995.9
12	2,010	2,006			

Barometer, 30″.44; thermometer, dry, 31 wet, 30°.

14. After twenty-four hours' exposure to a temperature of 120° F.

Number of shot.	No. 1 instrument.	No. 2 instrument.	Number of shot.	No. 1 instrument.	No. 2 instrument.
1	2,030	2,026	13	2,030	2,026
2	2,026	2,022	14	2,024	2,020
3	2,038	2,034	15	2,014	2,014
4	2,032	2,032	16	2,000	1,996
5	2,024	2,020	17	2,018	2,014
6	1,996	1,992	18	2,032	2,028
7	2,026	2,022	19	2,012	2,010
8	1,976	1,972	20	2,000	1,996
9	1,998	1,998			
10	2,000	2,000	Mean	2,014.9	2,012.0
11	2,018	2,016	Mean of two instruments.		2,013.4
12	2,004	2,002			

Barometer, 30″.43; thermometer, dry, 25°.

SECOND SERIES OF TESTS.

With the view of obtaining a check upon the accuracy of loading of cartridges heretofore used, it was thought desirable in repeating the tests with descending temperatures, to include cartridges from another lot of Du Pont powder. They were hand-loaded from lot No. 4 which required 38 grains. The large extreme variations in individual velocities were again apparent, and, as stated before, it is thought that these variations are due largely to inaccuracies in loading, and that in a repetition of the experiment better results could be obtained by weighing the charges on standard scales. The variations are not greater, however, than those given by machine-loaded cartridges.

1. Untreated cartridges, fired for standard Du Pont No. 4.

Number of shot.	No. 1 instrument.	No. 2 instrument.	Number of shot.	No. 1 instrument.	No. 2 instrument.
1	1,926	1,923	13	1,952	1,948
2	1,974	1,972	14	1,938	1,942
3	1,964	1,960	15	1,942	1,938
4	1,934	1,930	16	1,950	1,948
5	1,948	1,952	17	1,978	1,974
6	1,923	1,920	18	1,944	1,942
7	1,926	1,923	19	1,942	1,946
8	1,946	1,948	20	1,946	1,948
9	1,938	1,938			
10	1,942	1,940	Mean	1,946.4	1,945.3
11	1,958	1,954	Mean of two instruments.		1,945.8
12	1,958	1,960			

Barometer, 30''.37; thermometer, dry, 28°.

2. After twenty-four hours' exposure to a temperature of 120° F.

Number of shot.	Du Pont No. 1.		Du Pont No. 4.	
	No. 1 instrument.	No. 2 instrument.	No. 1 instrument.	No. 2 instrument.
1	2,006	2,002	2,026	2,026
2	2,012	2,008	2,010	2,012
3	2,014	2,028	2,024	2,024
4	2,022	2,018	2,042	2,042
5	2,018	2,014	2,012	2,008
6	2,030	2,034	2,018	2,014
7	2,022	2,022	2,022	2,020
8	2,022	2,020	2,026	2,026
9	2,026	2,026	2,026	2,024
10	2,006	2,004	2,018	2,014
Mean	2,017.8	2,017.6	2,022.4	2,021.0
Mean of two instruments	....	2,017.7	....	2,021.7

Barometer, 30''.37, thermometer, dry, 28°.

3. After twenty-four hours' exposure to a temperature of 110° F.

Number of shot.	Du Pont No. 1.		Du Pont No. 4.	
	No. 1 instrument.	No. 2 instrument.	No. 1 instrument.	No. 2 instrument.
1	2,022	2,022	1,990	1,990
2	2,018	2,018	1,980	1,982
3	1,976	1,976	1,998	1,994
4	1,976	1,972	2,010	2,014
5	1,998	2,002	2,010	2,006
6	1,998	1,992	2,014	2,010
7	1,986	1,982	1,994	1,990
8	1,996	1,990	2,022	2,014
9	1.998	1,994	1,986	1,982
10	2,002	2,002	2,010	2,006
Mean	1,997.0	1,995.0	2,001.4	1,998.8
Mean of two instruments	....	1,996.0	....	2,000.1

Barometer, 30''.30; thermometer, dry, 40°, wet, 35°.

4. After twenty-four hours' exposure to a temperature of 100° F.

Number of shot.	Du Pont No. 1.		Du Pont No. 4.	
	No. 1 instrument.	No. 2 instrument.	No. 1 instrument.	No. 2 instrument.
1	2,008	2,004	2,010	2,006
2	1,996	1,990	1,986	1,986
3	1,998	1,994	2,014	2,012
4	2,002	2,000	1,992	1,988
5	1,976	1,976	1,982	1,980
6	1,998	1,996	1,994	1,994
7	1,984	1,984	1,980	1,984
8	1,996	1,996	1,990	1,994
9	1,978	1,982	2,002	2,002
10	1,984	1,982	1,980	1,976
Mean	1,992.0	1,990.4	1,993.0	1,992.2
Mean of two instruments	....	1,991.2	....	1,992.6

Barometer, 30″.20; thermometer, dry, 47°, wet, 43°.

5. After twenty-four hours' exposure to a temperature of 90° F.

Number of shot.	Du Pont No. 1.		Du Pont No. 4.	
	No. 1 instrument.	No. 2 instrument.	No. 1 instrument.	No. 2 instrument.
1	1,982	1,986	2,002	2,002
2	2,000	2,000	2,000	2,004
3	1,990	1,988	1,956	1,962
4	1,982	1,982	1,954	1,954
5	1,982	1,980	2,006	2,008
6	1,998	1,996	1,996	2,000
7	1,992	1,994	1,952	1,948
8	1,972	1,976	1,978	1,972
9	1,990	1,990	1,984	1,976
10	2,000	2,000	2,006	2,006
Mean	1,988.8	1,989.2	1,983.4	1,983.2
Mean of two instruments	....	1,989.0	....	1,983.3

Barometer, 30″.15; thermometer, dry, 50°, wet, 47°.

6. After twenty-four hours' exposure to a temperature of 80° F.

Number of shot.	Du Pont No. 1.		Du Pont No. 4.	
	No. 1 instrument.	No. 2 instrument.	No. 1 instrument.	No. 2 instrument.
1	1,948	1,944	1,956	1,960
2	1,966	1,962	1,968	1,964
3	1,962	1,956	1,954	1,952
4	1,966	1,962	1,966	1,964
5	1,970	1,966	1,980	1,974
6	1,968	1,964	1,964	1,960
7	1,970	1,966	1,962	1,958
8	1,984	1,982	1,966	1,962
9	1,980	1,976	1,958	1,954
10	1,962	1,956	1,956	1,956
Mean	1,967.6	1,963.4	1,963.0	1,960.4
Mean of two instruments	....	1,965.5	....	1,961.7

Barometer, 30″.15; thermometer, dry, 57°, wet, 53°.

7. After twenty-four hours' exposure to a temperature of 70° F.

Number of shot.	Du Pont No. 1.		Du Pont No. 4.	
	No. 1 instrument.	No. 2 instrument.	No. 1 instrument.	No. 2 instrument.
1	1,970	1,972	1,962	1,956
2	1,948	1,946	1,956	1,952
3	1,934	1,936	1,956	1,960
4	1,974	1,970	1,984	1,982
5	1,956	1,956	1,972	1,968
6	1,984	1,984	1,944	1,942
7	1,968	1,964	1,970	1,966
8	1,950	1,946	2,000	1,998
9	1,968	1,964	1,954	1,950
10	1,952	1,958	1,948	1,950
Mean	1,960.4	1,959.6	1,964.6	1,962.4
Mean of two instruments	....	1,960.0	....	1,963.5

Barometer, 30''.20; thermometer, dry, 43°, wet, 42°.

8. After twenty-four hours' exposure to a temperature of 60° F.

Number of shot.	Du Pont No. 1.		Du Pont No. 4.	
	No. 1 instrument.	No. 2 instrument.	No. 1 instrument.	No. 2 instrument.
1	1,958	1,956	1,960	1,956
2	1,964	1,962	1,948	1,946
3	1,944	1,940	1,921	1,923
4	1,978	1,978	1,938	1,942
5	1,960	1,956	1,944	1,940
6	1,976	1,980	1,942	1,940
7	1,950	1,954	1,974	1,970
8	1,966	1,970	1,946	1,948
9	1,978	1,978	1,938	1,934
10	1,926	1,926	1,942	1,934
Mean	1,960.0	1,960.0	1,945.3	1,943.3
Mean of two instruments	....	1,960.0	....	1,944.3

Barometer, 29''.79; thermometer, dry, 49°, wet, 44°.

9. After twenty-four hours' exposure to a temperature of 50° F.

Number of shot.	Du Pont No. 1.		Du Pont No. 4.	
	No. 1 instrument.	No. 2 instrument.	No. 1 instrument.	No. 2 instrument.
1	1,940	1,936	1,954	1,952
2	1,934	1,930	1,923	1,918
3	1,926	1,923	1,948	1,944
4	1,946	1,942	1,925	1,923
5	1,914	1,910	1,938	1,934
6	1,916	1,912	1,925	1,920
7	1,942	1,936	1,942	1,942
8	1,925	1,922	1,946	1,942
9	1,946	1,942	1,954	1,950
10	1,954	1,950	1,938	1,942
Mean	1,934.3	1,930.3	1,939.3	1,936.7
Mean of two instruments	....	1,932.3	....	1,938.0

Barometer, 29''.86; thermometer, dry, 53°, wet, 46°.

10. After twenty-four hours' exposure to a temperature of 40° F.

Number of shot.	Du Pont No. 1.		Du Pont No. 4.	
	No. 1 instrument.	No. 2 instrument.	No. 1 instrument.	No. 2 instrument.
1	1, 978	1, 974	1. 928	1, 930
2	1, 944	1, 946	1, 938	1, 942
3	1, 954	1, 954	1. 944	1, 944
4	1, 958	1, 954	1, 925	1, 923
5	1, 954	1, 958	1, 936	1. 938
6	1, 942	1, 942	1, 912	1. 916
7	1, 938	1, 936	1, 934	1, 934
8	1, 946	1, 944	1, 954	1, 952
9	1, 966	1, 966	1, 940	1, 936
10	1, 962	1, 958	1, 942	1, 942
Mean	1, 954. 2	1, 953. 2	1, 935. 3	1, 935. 7
Mean of two instruments	....	1, 953. 7	....	1, 935. 5

Barometer, 30''.10; thermometer, dry, 48°, wet, 43°.

11. After twenty-four hours' exposure to a temperature of 30° F.

Number of shot.	Du Pont No. 1.		Du Pont No. 4.	
	No. 1 instrument.	No. 2 instrument.	No. 1 instrument.	No. 2 instrument.
1	1, 942	1, 938	1, 916	1, 912
2	1, 946	1, 944	1, 886	1, 886
3	1, 905	1, 905	1, 914	1, 910
4	1, 926	1, 923	1, 903	1, 901
5	1, 925	1, 921	1, 914	1, 914
6	1, 946	1, 946	1, 918	1, 916
7	1, 926	1, 923	1, 920	1, 916
8	1, 926	1, 926	1, 956	1, 960
9	1, 905	1, 908	1, 926	1, 923
10	1, 942	1, 942	1, 938	1, 936
Mean	1, 928. 9	1, 927. 6	1, 919. 1	1, 917. 4
Mean of two instruments	....	1, 928. 2	....	1, 918. 2

Barometer, 30''.09; thermometer, dry, 49°, wet, 45°.

12. After twenty-four hours' exposure to a temperature of 20° F.

Number of shot.	Du Pont No. 1.		Du Pont No. 4.	
	No. 1 instrument.	No. 2 instrument.	No. 1 instrument.	No. 2 instrument.
1	1, 974	1, 970	1, 908	1, 905
2	1, 950	1, 946	1, 905	1, 902
3	1, 944	1, 940	1, 920	1, 916
4	1, 962	1, 958	1, 905	1, 903
5	1, 946	1, 942	1, 914	1, 912
6	1, 954	1, 950	1, 927	1, 925
7	1, 938	1, 938	1, 942	1, 938
8	1, 944	1, 942	1, 938	1, 940
9	1, 954	1, 950	1, 932	1, 934
10	1, 948	1, 946	1, 890	1, 887
Mean	1, 951. 4	1, 948. 2	1, 918. 1	1, 916. 2
Mean of two instruments	....	1, 949. 8	....	1, 917. 1

Barometer, 29''.77; thermometer, dry, 55°, wet, 50°.

13. After twenty-four hours' exposure to a temperature of 10° F.

Number of shot.	Du Pont No. 1.		Du Pont No. 4.	
	No. 1 instrument.	No. 2 instrument.	No. 1 instrument.	No. 2 instrument.
1	1,885	1,886	1,855	1,851
2	1,910	1,908	1,885	1,888
3	1,900	1,896	1,910	1,912
4	1,974	1,972	1,921	1,921
5	1,990	1,992	1,890	1,894
6	1,992	1,992	1,868	1,870
7	1,952	1,952	1,890	1,894
8	1,946	1,944	1,918	1,916
9	1,925	1,923	1,938	1,938
10	1,960	1,962	1,906	1,910
Mean	1,943.4	1,942.7	1,898.1	1,899.4
Mean of two instruments		1,943.0		1,898.7

Barometer, 30''.10; thermometer, dry, 48°, wet, 42°.

14. After twenty-four hours' exposure to a temperature of 0° F.

Number of shot.	Du Pont No. 1.		Du Pont No. 4.	
	No. 1 instrument.	No. 2 instrument.	No. 1 instrument.	No. 2 instrument.
1	1,898	1,894	1,886	1,885
2	1,905	1,901	1,923	1,923
3	1,942	1,938	1,870	1,866
4	1,962	1,956	1,916	1,918
5	1,934	1,932	1,916	1,912
6	1,928	1,925	1,901	1,905
7	1,942	1,940	1,905	1,901
8	1,942	1,942	1,886	1,883
9	1,940	1,936	1,905	1,905
10	1,946	1,942	1,912	1,908
Mean	1,933.9	1,930.6	1,902.0	1,900.6
Mean of two instruments		1,932.2		1,901.3

Barometer, 29''.98; thermometer, dry, 33°, wet, 32°.

ADDITIONAL DATA.

The official correspondence, originating with the request of the commanding officer of the armory that the experiment herein reported upon be made, shows a diversity of opinion as to the time required to produce a given change of temperature in the powder in a loaded cartridge.

As this subject is of considerable importance in view of the possible increase in pressure from smokeless powder—resulting from allowing a loaded cartridge to rest for several minutes in the chamber of a machine gun after rapid and continuous fire—it is referred to here in order to present some data which may be of interest to the Department.

The commanding officer of the armory requested that, in order to produce a change of 10° F. in temperature, the cartridges be exposed to air having the desired temperature for from two to three days.

Indorsements from this arsenal expressed the opinion that an exposure of two hours would suffice, and recommended later an exposure of not more than eight hours.

An exposure of twenty-four hours was prescribed for the tests.

Under direction of the writer the tests described below were made by the chemist in the chemical laboratory at this arsenal.

REPORT ON CONDUCTIVITY OF POWDER WHEN EXPOSED TO HEATED ENVIRONMENT.

Three kinds of powder were used for this experiment, viz, Peyton, Laflin & Rand's W.-A., and Du Pont's black powder.

A tube of copper (0.025-inch thickness of copper) 3 inches long and 1¼ inches interior diameter was filled with each of these powders in succession. When full the tube was corked, with cork pressing firmly on the powder, and a thermometer passed through the cork and embedded in the powder so as to be equidistant from the circumference and the bottom of the tube; or, in other words, a layer of powder five-eighths inch thick surrounded the bulb of the thermometer. The weight of powder in case was 782 grains, or about 20 service charges.

The tube was then placed in a water oven regulated to a temperature of 129° to 131° F.

Peyton and Laflin & Rand W.-A. powders rose only 5.4° in the first ten minutes, but Du Pont's black powder rose 21.6° in the same time, showing a much greater conductivity than the first two powders. In the second period of ten minutes the Laflin & Rand W.-A. showed the greatest gain in temperature, as it also did in the third period. From that time the three powders rose very equally and very slowly, gradually reaching the temperature of the oven, the rate of increase rapidly diminishing as the powder approached the temperature of its surroundings.

The table accompanying this shows the increase in temperature of each powder, respectively, for each consecutive period of ten minutes. It also shows the rise in temperature of air in empty case.

Table showing the rise of temperature in successive periods of ten minutes for each kind of powder, 782 grains in case.

	Peyton, 1896, No. 15.		Laflin & Rand W.-A. No. 5.		Du Pont's black powder.		Empty case for comparison.	
	Temperature.	Difference.	Temperature.	Difference.	Temperature.	Difference.	Temperature.	Difference.
	° F.	° F.	° F.	° F.	° F.	° F.	° F.	° F.
Temperature at start	86	....	75.2	....	78.4	....	80.6	....
First ten minutes	91.4	5.4	80.6	5.4	95	21.6	105.7	25.1
Second ten minutes	100.4	9	95	14.4	104	9	123.8	18.1
Third ten minutes	111.2	10.8	108.5	13.5	113	9	127.4	3.6
Fourth ten minutes	118.4	7.2	114.8	6.3	118.4	5.4	130.5	3.1
Fifth ten minutes	123.8	5.4	119.3	4.5	123.8	5.4	....	....
Sixth ten minutes	126.5	2.7	122	2.7	125.6	1.8	....	....
Seventh ten minutes	128.3	1.8	124.7	2.7	127.4	1.8	....	....
Eighth ten minutes	129.7	1.4	125.6	0.9	129.2	1.8	....	....
Ninth ten minutes	131	1.3	127.4	1.8	131	1.8	....	....
Tenth ten minutes	131	....	128.3	0.9	....	....	....	....
Eleventh ten minutes	132.8	1.8	129.2	0.9	....	....	....	....
Twelfth ten minutes	....	....	129.2	....	....	....	....	....

	Total time.		Total increase in temperature.
	Hr.	Min.	° F.
Peyton's, 1896, No. 15 powder	1	50	46.8
Laflin & Rand's W.-A. No. 5 powder	2	00	54
Du Pont's black powder	1	30	57.6
Empty case for comparison	0	40	49.9

W. J. WILLIAMS, *Chemist.*

The metallic parts of the service .30-caliber cartridge have a higher conductivity for heat than has the powder charge, and in the cartridge the ratio of metallic surface in contact with the powder to volume of charge is much greater than in the experimental copper tube. The volume of powder in tube was twenty times the volume in charge.

These facts support the conclusion that the temperature in powder charge of a loaded cartridge will rise at least as rapidly as it did in the volume of powder contained in copper tube.

The longest time consumed in raising the temperature of powder in tube was two hours, and the actual rise of temperature during that time was 54° F. The rate of increase in temperature is of course a function of the difference in temperatures of powder and chamber. The times required to raise the temperatures through the last 10°, in bringing them to temperature of chamber, were about as follows: Peyton, 1 hour; Laflin & Rand W.-A., 1 hour 10 minutes; Du Pont black, 40 minutes; air, 20 minutes.

The following data obtained during progress of this investigation corroborate above results:

After the cartridges had been kept for twenty-two hours at 10° F., second series of tests, 10 extra cartridges from the lot of cartridges loaded with Du Pont powder, lot No. 4, and used in regular tests, were placed in the temperature chamber. At this time these extra cartridges had a temperature of about 70°, due to their having been kept for more than a week in a room of that average temperature.

When the firing for velocity took place that day two hours later these extra cartridges were fired also, with the following results:

Mean velocity after twenty-four hours' exposure	1,898.7
Mean velocity after two hours' exposure	1,899.0

The same thing was done the next day while working on 0° temperature, with following results:

Mean velocity, lot No. 4 cartridges, after twenty-four hours' exposure	1,901.3
Mean velocity, lot No. 4 cartridges, after two hours' exposure	1,901.9

The extremely close concordance was accidental, since the tests as a whole do not show such uniformity in velocities.

It indicates, however, that nothing was gained by the twenty-two hours' extra exposure except the certainty that an exposure for twenty-four hours is sufficient.

The apparatus now on hand and the experience gained during this investigation will make it a comparatively easy matter to do similar work in the future. It can now be stated that, in seeking the effect on velocity of any given temperature between the limits of 0° and 120° F., it will not be necessary to make the work continuous.

If cartridges are brought to, say, 90° and fired, they can be permitted to cool during the night and then be brought the next day to 100° and fired with results as reliable as though they had been kept between the limits of 90° and 100° during the idle interval. If this were not the case, the conditions of experiments would not correspond to service conditions where the temperature of a cartridge is liable to rise and fall many times before the time of firing.

Upon completion of second series of tests, surplus cartridges from powder lots 1 and 4, which had passed successively through all the temperatures from 70° (temperature of room) up to 120°—the starting point—and then down to 0°, were allowed to come back to temperature of room.

Ten from each lot were then fired for velocity, with following results:

Lot No. 1	1,961.9
Lot No. 4	1,968.4
Mean	1,965.1

The means of the mean velocities obtained from lot 1 and lot 4 cartridges, second series of tests, for temperatures of 60° and 70° were 1,952 and 1,962 respectively.

The above mean, 1,965.1, is close enough to these results to warrant the above statement that the effect of temperature (0° to —120°) on velocity is temporary only.

SUMMARY OF DATA.

If we neglect decimals and take a mean of the 20 shots fired daily during the second series of tests, we can condense the observed data into the following table:

Table showing mean initial velocities obtained from .30-caliber ammunition which had, when fired, the temperatures given.

Temperatures.	Initial velocity. Mean of 20 shots. Temperature changed, by 10° increments, from 0° to 120° F.	Initial velocity. Mean of 20 shots. Temperature changed, by 10° decrements, from 120° to 0° F.	Means of velocities in columns 2 and 3.
1.	2.	3.	4.
° *F.*	*Feet per sec.*	*Feet per sec.*	*Feet per sec.*
Untreated.	1,955	1,950	1,952
0	1,931	1,918	1,925
10	1,966	1,921	1,944
20	1,952	1,933	1,943
30	1,952	1,923	1,938
40	1,947	1,945	1,946
50	1,948	1,936	1,942
60	1,949	1,952	1,951
70	1,974 } 1,965	1,962 } 1,959	1,966 } 1,962
80	1,972	1,964	1,968
90	1,983	1,986	1,985
100	1,991	1,992	1,992
110	1,996	1,998	1,997
120	2,014	2,020	2,017

As was to be expected, the above table shows inconsistencies, and it is evident that the individual mean results are influenced by causes other than changes in temperature.

There is, however, a marked tendency of velocity to rise and fall with the temperature. Since the mean temperatures of the loading room and of the proof house may be assumed as about 70° F. from October to May, inclusive, it is thought that the mean velocities given opposite brackets in the above table form satisfactory standards with which to compare the other mean velocities in order to ascertain, roughly, the variations in velocity due to changes in temperature.

The following table shows the data obtained in this way:

Temperatures.	Changes in initial velocity.		
	First series of tests.	Second series of tests.	Mean.
° F.			
0	—34	—41	—37.5
10	+ 1	—37	—18.0
20	—13	—26	—19.5
30	—13	—36	—24.5
40	—18	—14	—16.0
50	—17	—23	—20.0
60	—16	— 7	—11.5
70	+ 9	+ 3	+ 6.0
80	+ 7	+ 5	+ 6.0
90	+18	+27	+22.5
100	+26	+33	+29.5
110	+31	+39	+35.0
120	+49	+61	+55.0

Pl. II (Enc. 39) shows a graphical adjustment of the mean data given in above table.

The records of tests of contract powders at this arsenal during the past two years furnish data of great value for constructing the mean curve shown on this plate. From this source it is found that the mean increase of velocity under "heat-test cartridges" for all the lots of Peyton and Du Pont-Peyton powders tested is 65 feet per second, and the mean loss under "cold-test cartridges" is 40 feet per second. These results correspond to the temperatures +130° F. and —40° F., respectively. They are accepted for extremities of the mean curve, Pl. II, which is made to conform in other respects as nearly as practicable to the mean data given above.

From this mean curve the following table has been constructed:

Table showing changes in initial velocity of .30-caliber ammunition corresponding to temperatures between —40° and +130° F.

Temperatures.	Change in initial velocity.	Temperatures.	Change in initial velocity.
° F.	*Feet per sec.*	° F.	*Feet per sec.*
130	+65	40	—20
120	+53	30	—23
110	+42	20	—27
100	+31	10	—30
90	+20	0	—34
80	+10	—10	—37
70	Standard.	—20	—41
60	— 8	—30	—44
50	—15	—40	—48

REMARK.—The initial velocity stamped on original package of ammunition with dates from October to May inclusive should be assumed as corresponding to a temperature of 70° F., and from June to September inclusive, to 85° F.

Respectfully,
B. W. DUNN,
First Lieutenant, Ordnance Department, U. S. A.

The COMMANDING OFFICER, FRANKFORD ARSENAL, PA.

Approved and respectfully forwarded to the Chief of Ordnance, United States Army, in connection with 12th indorsement, O. O. file No. 12185—Enc. 30, dated December 16, 1896.

J. P. FARLEY,
Lieutenant-Colonel, Ordnance Department, U. S. A., Commanding.

(12185—Enc. 37)

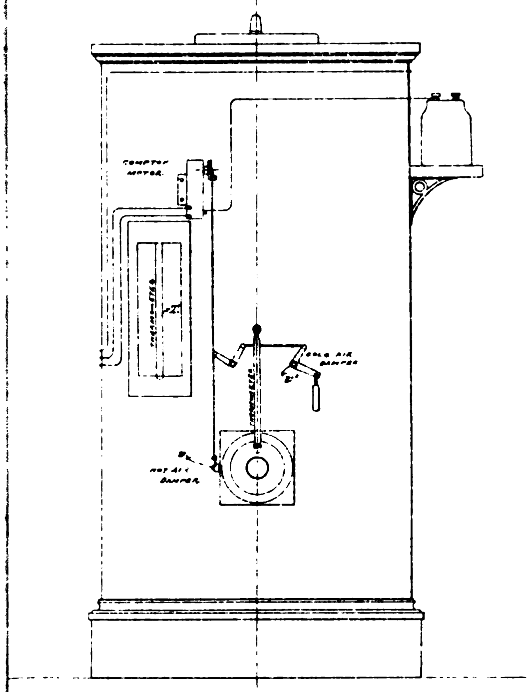
Plate I.

...ating and Refrigerating Apparatus.

Frankford Arsenal.

...of Inches.

Right Hand Side View. Fig. 3.



Appendix 11, 1897.

APPENDIX 12.

DEVIATION OF SMALL-ARM PROJECTILES DUE TO ARTIFICIAL WIND PRESSURE—EXPERIMENTS AT THE FRANKFORD ARSENAL, PA.

(5 plates.)

FRANKFORD ARSENAL,
Philadelphia, Pa., April 11, 1896.

SIR: I have the honor to submit the following partial report on experiments made to determine the pendulum deviations of .30 and .45 caliber bullets.

The apparatus for measuring deflections was constructed almost exactly as suggested by the Chief of Ordnance in his letter to the commanding officer, Frankford Arsenal, dated February 20, 1896.

DESCRIPTION OF APPARATUS.

The only source of wind artificially produced at this arsenal is the fan which supplies the blacksmith forge. This fan is 28 inches in diameter and has a normal speed of 1,855 revolutions per minute. A 6-inch main pipe, laid horizontally under floor of blacksmith shop, conducts the blast.

Connection with this main was made by means of the curved tin pipe g, fig. 1, Pl. I, which is joined to wooden tube e, by funnel f. The diameter of this wooden tube, 19.9 inches, permits the placing of anemometer inside the tube, as shown in figs. 1 and 5.

Platinum wire, annealed and less than 0.002 inch in diameter, was used to suspend bullets. The scale used in measuring deflections is shown in fig. 4. The vertical rod carrying point of suspension was steadied by four guys (not shown in drawing) passing from top of rod to the ends and sides of tube. The adjustment afforded by guys enabled the operator to make the vertical through point of suspension coincide with center of slot and zero of deflection scale. The slot in top of tube, fig. 4, is 0.05 inch wide and bordered by carefully smoothed and polished metal edges. The friction of wire on edges is inappreciable. The wire tends to stand free of contact with edges, and is brought into contact with them only by lateral vibrations.

In measuring velocity of wind with full opening, 19.9 inches, readings were taken with the anemometer in the two positions a and a', fig. 1. The ordinary anemometer furnished by signal department was used. It rings an electric tap bell for each tenth of mile. The time between taps was taken with a stop watch reading to quarter seconds. The mean of ten times so taken and reduced to miles per hour constituted one observation for wind velocity.

To increase wind velocity, a series of tin funnels, figs. 2 and 3, their larger ends fitting snugly in wooden tubes, were used. The diameters of smaller ends were 11.88, 9.52, 8.16, 7.02, and 6.04 inches, respectively. There was no appreciable escape of air between larger ends of funnels

and surface of wooden tube. The relative positions of deflected bullet and end of funnel are shown by fig. 2.

Since the radii of contracted outlets were less than length of anemometer arm, this instrument could not be used under normal conditions to measure the higher wind velocities. Readings were taken, however, with funnels and anemometer in relative positions shown by figs. 3 and 6, the mouth of funnel being brought as close as practicable to revolving cups, and the center of cup opposite center of funnel when cup arm was perpendicular to direction of wind.

In calculating higher velocities it was assumed that a constant volume of air passed per unit of time and that the wind velocities were inversely proportional to squares of diameters of openings.

Sliding pieces, h and h′, figs. 1 and 4, served to close slot in top of tube. No appreciable amount of air escaped through this slot.

The measurements of deflections obtained were the tangents of the angles of deflection for a radius of 109.13 inches.

The bullets did not, under action of blasts, take up new positions and remain there. They were kept almost constantly in motion, tending to vibrate in all directions, but principally backward and forward in direction of wind velocity. By carefully watching the wire and deflection scale for several minutes and noting the different positions on scale when wire tended for a short time to stand steady, the mean deflections and limits hereinafter given were obtained.

For example, with .45-caliber bullet and full opening of wooden tube it was noted that the wire seemed to vibrate, for short intervals of time, to equal distances on each side of the following divisions on scale (sixteenths of an inch from zero): 3, 3, 3, $3\frac{1}{2}$, 4, 3, 5, 5, 4, 3, 3.

$$\text{Mean} = \frac{3''.59}{16} = 0''.22. \quad \text{Maximum} = 0''.31. \quad \text{Minimum} = 0''.19.$$

Substituting the .30-caliber for .45-caliber bullet, the corresponding data were: 6, 5, 5, 6, 5, 5, 6, 7, 7, 7, 6, 8, 7, 6, 6.

$$\text{Mean} = \frac{6''.13}{16} = 0''.38. \quad \text{Maximum} = 0''.50. \quad \text{Minimum} = 0''.31.$$

The mean deflections were thus measured at different times and on different days, and in the table of condensed data hereafter submitted the mean of all mean deflections measured is given as the most probable deflection.

TABLE I.

Wind velocity data, miles per hour.						.45 caliber.			.30 caliber.		
Diameters of blast outlets.	Anemometer inside wooden tube. (Pl. I, fig. 1, a.)	Anemometer at mouth of wooden tube. (Pl. I, fig. 1, a′.)	Calculated for reduced areas of outlets from data in column 2.	Calculated for reduced areas of outlets from data in column 3.	Anemometer placed as shown in figs. 3 and 6. No retarding pressure on cups.	Mean deflections. Radius = 109″.13.	Mean limits of deflections. Minimum.	Mean limits of deflections. Maximum.	Mean deflections. Radius = 109″.13.	Mean limits of deflections. Minimum.	Mean limits of deflections. Maximum.
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
Inches.						*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
19.9	2.75	3.47	2.75	3.47	....	0.22	0.12	0.31	0.34	0.20	0.45
11.88	....	....	7.71	9.72	9.24	0.95	0.81	1.08	1.49	1.31	1.68
9.52	....	....	12.01	15.15	14.16	1.84	1.71	1.96	2.68	2.40	2.73
8.16	....	....	16.35	20.62	18.28	2.74	2.55	2.93	4.32	4.14	4.51
7.02	....	....	22.09	27.86	22.30	4.54	4.40	4.72	6.87	6.58	7.03
6.04	....	....	29.55	37.26	29.08	7.72	7.74	7.89	11.39	11.16	11.59

TABLE I—Continued.

Mean deflections, .45 caliber.	Mean deflections, .30 caliber.	.45 caliber. Horizontal deflecting force.	.30 caliber. Horizontal deflecting force.	.45 caliber. Component of deflecting force perpendicular to axis of bullet.	.30 caliber. Component of deflecting force perpendicular to axis of bullet.	Ratio. $\frac{\text{Deflecting force, .30 caliber.}}{\text{Deflecting force, .45 caliber.}}$	Ratio. $\frac{\text{Def. force per unit mass, .30 caliber.}}{\text{Def. force per unit mass, .45 caliber.}}$
13.	14.	15.	16.	17.	18.	19.	20.
° ′ ″	° ′ ″	*Grains.*	*Grains.*	*Grains.*	*Grains.*		
0 6 55.84	0 10 42.63	1.01	0.68	1.01	0.68	0.68	1.5455
0 29 55.54	0 46 56.05	4.35	3.00	4.35	3.00	0.69	1.5684
0 57 57.42	1 24 24.40	8.43	5.40	8.43	5.40	0.64	1.4565
1 26 17.74	2 16 0.90	12.58	8.71	12.55	8.70	0.69	1.5766
2 22 56.03	3 36 7.76	20.80	13.85	20.78	13.82	0.67	1.5132
4 2 47.18	5 57 30.38	35.37	22.96	35.28	22.84	0.65	1.4754
						Mean = 0.67	Mean = 1.5226

Range.	Ratio. $\frac{(\text{Time of flight})^2, .30 \text{ caliber.}}{(\text{Time of flight})^2, .45 \text{ caliber.}}$	Ratio. $\frac{\text{Deviation, .30 caliber.}}{\text{Deviation, .45 caliber.}}$
21.	22.	23.
Yards.		
200	0.422	0.6428
300	0.438	0.6665
400	0.448	0.6815
500	0.464	0.7066
600	0.499	0.7444
700	0.509	0.7754
800	0.528	0.8033
900	0.546	0.8313
1,000	0.552	0.8408
1,900	....	0.8905

REMARKS ON TABLE I.

Table I (Enc. 2) shows in condensed form the experimental data referring to service bullets, .45 and .30 caliber, and also some calculations based on this data.

(*a*) The anemometer placed at *a*, Pl. I, fig. 1, registers 2.75 miles per hour (column 2). This is a mean of nine measurements taken on different days. These measurements were 2.89, 2.76, 2.62, 2.63, 2.66, 2.95, 2.76, 2.74.

When placed at a^1, same figure, the measurements were 3.23, 3.33, 3.16, 3.65, 3.38, 3.68, 3.60, 3.71, 3.47—mean=3.47 (column 3).

Why the anemometer when placed at the mouth of tube should register higher than when placed inside must be explained before deciding which set of data is to be preferred.

The following suggestions on this point are submitted:

(1) The velocity of air in tube is a maximum at center of tube and decreases according to some unknown law to a minimum at the interior surface. The moment of air pressure producing revolution of cups is at a maximum when cup arm is perpendicular to axis of tube, and in this position the center of cup is in a region of relatively low velocity.

(2) As the air leaves the mouth of tube it has an outward as well as a forward motion.

This produces a change in direction of pressure during first quadrant of cup's revolution after leaving center of tube, and by consequent increase of lever arm increases moment of wind pressure.

(3) The probable errors of anemometer readings are greater for small than for large velocities.

(4) Since the bullet, in center of tube, is in the region of maximum velocity there would be no objection to taking the mean of these two records—2.75 and 3.47—for the most probable velocity given by the full opening of tube, were it not for the data given by column 6.

These data (column 6) come from registrations of anemometer under conditions which should give velocities much higher than the true velocities since the concave sides of cups only are subjected to pressure (Pl. I, figs 3 and 6). The retarding pressure on convex sides, which is considered in calibrating the instrument and which is ordinarily estimated as bearing a ratio of 1:2 to the accelerating pressure, is removed by the conditions imposed.

(5) Assuming, then, that the values in column 6 are too high, it shakes confidence in values in columns 4 and 5 to find them, as a general thing, still higher.

In presenting deflection curves as a function of wind velocity, no attempt is made to reconcile these contradictions.

Curves are submitted (Pls. II, III, and IV) corresponding to each of the three sets of data for wind velocities. The ordinates for curves in each case are taken from columns 7 and 10, and the abscissas from 4, 5, and 6, respectively.

Notwithstanding the inaccuracies referred to, it is thought that these curves, in connection with calculated data in columns 15, 16, 17, and 18, show that the deflecting force of winds increases more rapidly than the first power of wind velocity.

(*b*) The data given in columns 7 to 14, inclusive, are sufficiently explained by the headings. Each mean deflection given is the mean of at least seventy observations.

(*c*) The data in columns 15 to 18, inclusive, were calculated from the parallelogram of forces, wind pressure being assumed as horizontal in direction and acting at center of gravity of bullet.

(*d*) The values in column 19 afford a check on columns 7 and 10. The ratios in column 19 should be constant and apparently equal to the ratio of areas of longitudinal sections of .30 and .45 caliber bullets, which is about 0.65.

(*e*) The numbers in column 23 come from multiplying ratios in column 22 by the mean of ratios in column 20, and show the deviations of the .30 caliber, for ranges given, in terms of deviation of .45 caliber bullet, taken as unity. These computations are based upon the assumptions

that wind pressure acts as a constant force and that the area presented for its action in each case is the area of longitudinal section of bullet.

It is suggested that large errors are liable to result from these assumptions, especially the latter, since the bullet in flight maintains a volume of compressed air on front of and around its point, and the drifting of this volume, under the action of wind pressure, will materially affect the deviation of bullet. The effect of this volume of condensed air upon deviation may be equivalent to that of increasing in some degree the area exposed to wind pressure.

In that case, the expression for deviation in terms of time of flight and acceleration due to constant wind pressure should have a coefficient introduced, to be determined by experiment.

If the above suggestion has any value, we should expect to see the coefficient vary with the range, since the volume and density of compressed air is a function of bullet's velocity.

One interpretation of the letter of Chief of Ordnance, previously referred to, is that only the experimental data, and not a discussion of it, is desired by him.

The calculated data in Table I, not called for in the letter, and the general remarks thereon are submitted simply as suggestions for consideration in connection with the experimental data.

Lead cylinders, each 1 inch long and having diameters of 0.5, 0.45, 0.40, 0.35, 0.30, 0.25, and 0.20 inch, respectively, have been prepared; but, before proceeding further with the experiments, information is requested as to whether any changes in apparatus or programme should be made.

Respectfully, B. W. DUNN,
Lieutenant, Ordnance Department, U. S. A.

The COMMANDING OFFICER, FRANKFORD ARSENAL, PA.

FRANKFORD ARSENAL,
Philadelphia, Pa., April 13, 1896.

Approved and respectfully forwarded to the Chief of Ordnance, United States Army.

J. P. FARLEY,
Lieutenant-Colonel, Ordnance Department, U. S. A., Commanding.

(13788—Enc. 1)

II.

FRANKFORD ARSENAL,
Philadelphia, Pa., June 18, 1896.

SIR: I have the honor to submit the following report on "Wind pressures on lead cylinders of constant lengths and varying diameters":

In his letter of February 20, 1896, the Chief of Ordnance required data "in regard to the deviating force of wind pressure on bullets," and stated:

> * * * If you are able to make the experiments, include also some experiments on lead cylinders of equal lengths and varying diameters, these cylinders to be square at the ends, say about 1 inch long, and of diameters ranging from 0.2 to 0.5 inch. It has been assumed that the deviating effect increases directly as the diameter increases, and the object of the experiment on cylinders is to determine if this assumption is true.

On April 11, 1896, the writer submitted a partial report describing the experimental apparatus used, and giving the data obtained for .30 and .45 caliber bullets.

The concluding paragraph of this report stated:

Lead cylinders, each 1 inch long and having diameters of 0.5, 0.45, 0.40, 0.35, 0.30, 0.25, and 0.20 inch, respectively, have been prepared; but, before proceeding further with the experiments, information is requested as to whether any changes in apparatus or programme should be made.

No instructions were received, and, as your original instructions directed that the experiments outlined by the Chief of Ordnance be made and results reported from time to time, the apparatus, without modification, was used to obtain the data herein reported.

The exact weights and dimensions of lead cylinders are given in following table:

TABLE II.

Weight.	Lengths.	Diameters.	Weight of 1 cubic inch (calculated).
Grains.	*Inches.*	*Inches.*	*Grains.*
531.5	1.0048	.4990	2,593
435.8	1.0048	.4503	2,611
347.2	1.0018	.4003	2,754
264.8	1.0016	.3500	2,748
194.7	1.0041	.3004	2,736
133.7	1.0030	.2500	2,716
84.0	1.0021	.1990	2,695

These cylinders were machined from castings whose composition was supposed to be 16 parts of lead to 1 of tin, that of the .45-caliber bullet.

If the castings had been perfectly sound and specific gravities of lead and tin normal, 1 cubic inch of composition would have weighed 2,834 grains.

These cylinders were suspended as simple pendulums, exactly as described in previous report.

Considering the object in view, viz, to determine whether wind pressure varies directly with diameters, exact measurement of wind velocity is not important. It is necessary only to subject the different cylinders to the same blast.

The strength of blast was varied by using the same funnels.

The following table shows in columns 3 to 9 the mean measured deflections for the radius, 109.13 inches. The first value in column 2 is the mean velocity of wind as shown by anemometer placed at mouth of tube (a′ fig. 1, Pl. I, previous report). The succeeding values in this column are calculated from areas of outlets as previously described.

TABLE III.

		Mean pendulum deflections. (Radius=109.13 inches.)						
1.	2.	3.	4.	5.	6.	7.	8.	9.
Diameter of outlet.	Velocity of wind per hour.	.50 cylinder.	.45 cylinder.	.40 cylinder.	.35 cylinder.	.30 cylinder.	.25 cylinder.	.20 cylinder.
Inches.	*Miles.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
19.90	3.60	0.155	0.202	0.235	0.277	0.317	0.380	0.432
11.88	10.11	.692	.882	1.030	1.145	1.353	1.785	2.185
9.52	15.74	1.488	1.615	2.000	2.263	2.525	3.167	4.213
8.16	21.43	2.333	2.608	2.963	3.513	4.063	5.125	6.588
7.02	28.95	3.725	4.140	4.600	5.235	6.308	7.770	9.870
6.04	39.11	6.163	7.013	7.860	9.110	10.017	13.017	(*)

* Deflection beyond limits of scale.

Assuming that wind pressure (W_n) is a horizontal force applied at the center of gravity of cylinder, we have, from parallelogram of forces, α being the deflection angle and W the weight of cylinder,

$$W_n = W \tan. \alpha = W \frac{\text{mean deflection}}{109.13.}$$

TABLE IV.

Velocity of wind per hour.	Wind pressure.						
	.50 cylinder.	.45 cylinder.	.40 cylinder.	.35 cylinder.	.30 cylinder.	.25 cylinder.	.20 cylinder.
1.	2.	3.	4.	5.	6.	7.	8.
Miles.	*Grains.*	*Grains.*	*Grains.*	*Grains.*	*Grains.*	*Grains.*	*Grains.*
3.60	0.7549	0.8055	0.7477	0.6714	0.5650	0.4656	0.3325
10.11	3.3703	3.5222	3.2770	2.7783	2.4130	2.1869	1.6818
15.74	7.2446	6.4493	6.3630	5.4899	4.5049	3.8806	3.2425
21.43	11.3600	10.413	9.4253	8.5230	7.2480	6.2780	5.0706
28.95	18.142	16.533	14.635	12.703	11.253	9.5194	7.5972
39.11	30.017	28.007	25.007	22.105	17.870	15.948	....

The data in Table IV are shown graphically by Plate V. The values of wind pressure for given velocities of wind are plotted as ordinates, the corresponding abscissas being the diameters of cylinders.

The resulting curves seem to justify the assumption that wind pressure increases directly with the diameters of cylinders.

Very respectfully,

B. W. DUNN,
Lieutenant, Ordnance Department, U. S. A.

The COMMANDING OFFICER, FRANKFORD ARSENAL, PA.

FRANKFORD ARSENAL,
Philadelphia, Pa., June 24, 1896.

Approved, and respectfully forwarded to the Chief of Ordnance, United States Army, in connection with report on same subject forwarded April 13, 1896.

J. P. FARLEY,
Lieutenant-Colonel, Ordnance Department, U. S. A., Commanding.

(13788—Enc. 7)

APPENDIX 13.

REPORT OF TESTS OF SMOKELESS POWDER FOR SMALL ARMS BY THE SMOKELESS POWDER BOARD, FRANKFORD ARSENAL, PA.

[I. Weidig No. 1, for .30-caliber rifle; II. Weidig Nos. 2 and 3, for .45-caliber rifle; III. Weidig samples No. 1, for .30-caliber, and No. 2, for .45-caliber rifle; IV. Rottweil, for .30-caliber rifle; V. Savage, for .30-caliber rifle.]

I.

FRANKFORD ARSENAL,
Philadelphia, Pa., March 31, 1897.

SIR: The board for the tests of contract powders has the honor to submit the following report of test of a sample of Weidig smokeless powder, for .30-caliber U. S. magazine rifle, received March 9, 1897.

The record of test is as follows:

Sample Weidig No. 1 smokeless powder, for .30-caliber rifle, March 13, 1897.

PRESSURE GUN NO. 21.

[Charge, 33.3 grains; 220 grains nickeled-steel jacketed bullet.]

Velocity at 53 feet from muzzle.	Pressure per square inch. Initial.	Pressure per square inch. Final.	Primer.	Remarks.
Feet per second.		*Pounds.*		
1,873	Mean initial compression, 30,000 pounds.	39,500	G_{36}	Maximum pressure, 40,250 pounds; minimum pressure, 32,600 pounds. Velocity, extreme variation, 75 feet per second; mean variation, 22.90 feet per second. Barometer, 30''.25. Thermometer, dry bulb, 44°; wet bulb, 40°.
1,906		37,400		
1,926		40,250		
1,855		32,600		
1,916		38,800		
1,851		33,400		
1,908		37,800		
1,870		33,000		
1,883		36,500		
1,905		37,650		
Mean.. 1,889.3	....	36,690		

U. S. MAGAZINE RIFLE NO. 18647.

1,815	....	....	G_{36}	Velocity, extreme variation, 55 feet per second; mean variation, 16.08 feet per second. Barometer, 30''.25. Thermometer, dry bulb, 44°; wet bulb, 40°.
1,870	....	....		
1,862	....	....		
1,870	....	....		
1,855	....	....		
1,848	....	....		
1,835	....	....		
1,838	....	....		
1.818	....	....		
1.855	....	....		
Mean.. 1,846.6	....	....		

Stability, no trace in sixty minutes.

In view of the low velocity (1,847 feet per second), corresponding to a pressure of 36,690 pounds per square inch, the board recommends that no further test be made of this powder.

Respectfully, for the board,

B. W. DUNN,
First Lieutenant, Ordnance Department, U. S. A., President.

The COMMANDING OFFICER, FRANKFORD ARSENAL, PA.

FRANKFORD ARSENAL, PA., *April 1, 1897.*

Approved and respectfully forwarded to the Chief of Ordnance, United States Army, in connection with 4th indorsement on letter No. 19726, of this date.

J. M. WHITTEMORE,
Colonel, Ordnance Department, U. S. A., Commanding.

(19726—Enc. 3)

II.

FRANKFORD ARSENAL,
Philadelphia, Pa., March 31, 1897.

SIR: The board for the tests of contract powders has the honor to submit the following report on two samples of Weidig smokeless powder, received March 9, 1897, and tested in the .45-caliber Springfield rifle and pressure gun.

The record of test of these powders is as follows:

Sample Weidig No. 2 smokeless powder, for .45-caliber rifle, March 19, 1897.

PRESSURE GUN NO. 2, CALIBER .45.

[Charge, 29.5 grains; 500 grains lead bullet.]

Velocity at 53 feet from muzzle.	Pressure per square inch. Initial.	Pressure per square inch. Final.	Primer.	Remarks.
Feet per second.		*Pounds.*		
1,376.5	Mean initial compress on, 18,000 pounds.	21,400	G.$_{36}$	Velocity, extreme variation, 53 feet per second; mean variation, 16.80 feet per second. Barometer, 30″.8. Thermometer, dry bulb, 44°; wet bulb, 44°.
a 1,343.0		18,800		
a 1,344.0		19,900		
1,394.0		26,900		
a 1,341.0		18,000		
1,362.0		21,500		
1,344.0		18,900		
1,344.0		18,800		
1,382.0		18,200		
1,369.5		21,500		
Mean.. 1,360.0	....	20,390		

a Very short hang fires.

Sample Weidig No. 2 smokeless powder, for .45-caliber rifle, March 19, 1897—Cont'd.

U. S. SPRINGFIELD RIFLE NO. 248538.

[March 19, 1 set; March 27, 2 sets.]

Velocity at 53 feet from muzzle.	Pressure per square inch.		Primer.	Remarks.
	Initial.	Final.		
Feet per second.		*Pounds.*		
1,383.5	....	1,361.0	G.36	Velocity, 20 shots, extreme variation, 35 feet per second: mean variation, 8.77 feet per second. Barometer, 30".08. Thermometer, dry bulb, 44°; wet bulb, 44°.
a 1,387.0	....	1,394.0		
a 1,369.5	....	1,392.0		
1,394.0	....	1,396.0		
1,383.0	....	1,369.5		
1,385.0	....	1,379.0		
a 1,374.0	....	1,376.5		
1,387.0	....	a 1,385.0		
a 1,368.0	....	a 1,375.0		
1,375.0	....	a 1,363.5		
Mean.. 1,380.6	....	1,379.1		

a Hung fire.

Mean of 20 shots, 1,380 feet per second. Stability, no trace in sixty minutes.

Sample Weidig No. 3 smokeless powder for .45 caliber rifle, March 24, 1897.

PRESSURE GUN NO. 2, CALIBER .45.

[Charge, 26 grains; 500 grains lead bullet.]

Velocity at 53 feet from muzzle.	Pressure per square inch.		Primer.	Remarks.
	Initial.	Final.		
Feet per second.		*Pounds.*		
1,358	Mean initial compression 18,000 pounds.	24,900	G.36	Maximum pressure, 27,650 pounds; minimum pressure, 20,500 pounds. Velocity, extreme variation, 40 feet per second; mean variation, 9.04 feet per second. Barometer, 29".33. Thermometer, dry bulb, 53°; wet bulb, 47°.
1,353		21,600		
1,343		20,500		
1,366		27,650		
1,343		25,400		
1,353		27,000		
1,351		20,600		
1,334		25,350		
1,326		24,400		
1,351		22,150		
Mean.. 1,347.8	....	23,955		

U. S. SPRINGFIELD RIFLE NO. 248538.

1,343	....	....	G.36	Velocity, extreme variation, 57 feet per second; mean variation, 10.60 feet per second. Barometer, 29".33. Thermometer, dry bulb, 53°; wet bulb, 47°.
1,319	....	....		
1,374	....	....		
1,344	....	....		
1,336	....	....		
1,351	....	....		
1,359	....	....		
1,376	....	....		
1,359	....	....		
1,361	....	....		
Mean.. 1,352.2	....	....		

Stability, no trace in sixty minutes.

Of the two samples, No. 2 is the more promising. In view of the velocity (1,380 feet per second, instrumental—1,410 muzzle velocity) obtained with a pressure of 20,400 pounds, the board recommends that a larger sample of No. 2 powder be procured with a view to putting it through the regular tests now prescribed for the smokeless powder for the .30-caliber U. S. magazine rifle.

The form of the grain of this powder is not adapted to the loading machine at this arsenal. If a larger sample be procured, it is recommended that Dr. Weidig be requested to inform the Department if the form of grain of this powder can be modified to permit of machine loading.

Respectfully, for the board.

B. W. DUNN.
Lieutenant, Ordnance Department, U. S. A., President.

The COMMANDING OFFICER, FRANKFORD ARSENAL, PA.

FRANKFORD ARSENAL,
Philadelphia, Pa., April 1, 1897.

Approved and respectfully forwarded to the Chief of Ordnance, United States Army, in connection with 4th indorsement on letter No. 19726 of this date.

J. M. WHITTEMORE,
Colonel, Ordnance Department, U. S. A., Commanding.

(19726—Enc. 4)

III.

FRANKFORD ARSENAL,
Philadelphia, Pa., June 11, 1897.

SIR: The smokeless powder board has the honor to submit the following report on two samples of Weidig powder, pursuant to the 2d indorsement on the following letter from Dr. H. P. Weidig:

THE COLUMBIA CHEMICAL FIRE ENGINE, UNITED STATES PATENT,
Corner Clifford and Van Buren Streets, Newark, N. J., April 14, 1897.

Gen. DAN. W. FLAGLER, U. S. A.,
Chief of Ordnance Department, Washington, D. C.

SIR: Your esteemed favor of 13th instant duly received. I am surprised to learn that powder No. 1 did not give the results I expected. The tests here showed for 8 millimeters caliber, 2.55 gram charge, 14.7 gram bullet, 2.500 atmospheres pressure and 602 meters initial velocity; for 7.65 millimeters caliber, 2.25 gram charge, 13.6 gram bullet, 2.300 atmospheres pressure and 590 meters initial velocity. I send you to-day, express prepaid, a large sample of powder No. 2 and another small sample of No. 1. Please have it retested.

I wish to state that I am ready to furnish the gun cotton for these powders to the amount of 800 pounds per day.

Very respectfully,

H. P. WEIDIG.

Reply to your No. 19726.

[First indorsement.]

OFFICE OF THE CHIEF OF ORDNANCE,
Washington, April 17, 1897.

Respectfully referred to the commanding officer, Frankford Arsenal, with instructions to test the samples of powder when received, they being sent separately, in one package, by express.

The results of the last samples of Weidig powder—Nos. 1, 2, and 3—were communicated to Dr. Weidig, and this letter is a reply thereto. Dr. Weidig was requested to state if the powder could be adapted to machine loading with the machines now in use at Frankford Arsenal, but has neglected to answer that inquiry.

By order of the Chief of Ordnance:

R. BIRNIE,
Captain, Ordnance Department, U. S. A.

[Second indorsement.]

FRANKFORD ARSENAL, PA., *April 20, 1897.*

Respectfully referred to the smokeless powder board for test of Dr. H. P. Weidig's samples No. 1 and No. 2, and report thereon.

J. M. WHITTEMORE,
Colonel, Ordnance Department, U. S. A., Commanding.

The record of test of both samples is inclosed.

Sample No. 1, for the .30-caliber U. S. magazine rifle, does not give the required velocity within the limit of pressure allowed. Its test was therefore limited to that herein reported.

The test of sample No. 2, for the .45-caliber Springfield rifle, was carried as far as the limited amount of the sample furnished allowed.

The result of the test so far would be satisfactory except for the fact that the grain of the powder does not permit of machine loading with the machines on hand at this arsenal.

A report of test of Du Pont black powder for heat and moisture is inclosed for comparison.

Respectfully submitted.

J. PITMAN,
Major, Ordnance Department, U. S. A., President.
B. W. DUNN,
First Lieutenant, Ordnance Department, U. S. A., Member.
COLDEN L'H. RUGGLES,
First Lieutenant, Ordnance Department, U. S. A., Recorder.

The COMMANDING OFFICER, FRANKFORD ARSENAL, PA.

FRANKFORD ARSENAL,
Philadelphia, Pa., June 14, 1897.

Approved and respectfully forwarded to the Chief of Ordnance, United States Army, in connection with 4th indorsement on letter No. 19726—Enc. 5.

J. M. WHITTEMORE,
Colonel, Ordnance Department, U. S. A., Commanding.

(19726—Enc. 6)

Record of tests of Weidig No. 1 smokeless powder for

Date.	Gun.	Nature of test.	Powder charge. Kind.	Powder charge. Weight.	Bullet, kind and weight.	Shots fired.	Mean velocity at 53 feet from muzzle.
1897.				*Grains.*		*No.*	*Ft. sec.*
May 18	Pressure gun, caliber .30, No. 21.	Standard ...	Weidig No. 1 smokeless. Received Apr. 19, 1897.	33.3	Nickel-steel jacket 220 grains.	10	1,877.4
May 18	.....do	.....do	.....do	33.4	.....do	5	1,932.6
May 19	.....do	.....do	.....do	33.5	.....do	5	1,939.4

Designation (including date of receipt, quantity, etc.) of lot or sample of powder tested: Weidig No. 1 smokeless powder. Received April 19, 1897.

Record of tests of Weidig No. 2 smokeless powder for

Date.	Gun.	Nature of test.	Powder charge. Kind.	Powder charge. Weight.	Bullet, kind and weight.	Shots fired.	Mean velocity at 53 feet from muzzle.	Variation in velocity. Extreme.	Variation in velocity. From standard.
1897.				*Grains.*		*No.*	*Ft. sec.*	*Ft. sec.*	*Ft. sec.*
May 25..	Springfield rifle, caliber .45, No. 248538.	Standard (cartridges)...	Weidig No. 2 smokeless powder for caliber .45 small arms. Received Apr. 19, 1897.	26.5	Lead, caliber .45, 500 grains.	10	1,303.5	45.0	....
May 25..		Heat....................		26.5		10	1,293.7	34.0	— 9.8
June 2..		Standard (powder)......		26.5		20	1,300.5	37.0	....
June 2..		Heat....................		26.5		10	1,351.5	22.0	+51.0
June 2..		Moisture		26.5		10	1,229.0	47.0	—71.5
June 2..		Moisture and air		26.5		10	1,290.4	24.0	—10.1
May 25	Pressure gun, caliber .45, No. 2.	Standard (cartridges)...		26.5		5	1,324.3	52.0	....
May 25..		Heat....................		26.5		5	1,377.3	19.0	—53.0
June 2..		Standard (powder)......		26.5		10	1,295.1	30.0	....
June 2..		Heat....................		26.5		5	1,318.3	31.0	—23.2
June 2..		Moisture................		26.5		5	1,245.1	32.0	—50.0
June 2..		Moisture and air........		26.5		5	1,304.0	31.0	— 8.9

Accuracy at 500 yards.

Radius.	M. V. D.
0'.90	0'.590
.80	.685
.76	.450
.64	.585
.87	.750
5) 3.97	5) 3.060
0.794	0.612

.30-caliber small arms, at Frankford Arsenal, Pa.

Variation in velocity.		Mean variation in velocity.	Initial compression of cylinder per square inch.	Powder pressure per square inch.		Machine loading,—charges.		Barometer.	Thermometer.		Primer.	Remarks.
Extreme.	From standard.			Mean.	Extreme.	Extreme variation.	Mean variation.		Dry bulb.	Wet bulb.		
Ft. sec.	*Ft. sec.*	*Ft. sec.*	*Lbs.*	*Lbs.*	*Lbs.*	*Grs.*	*Grs.*	*Ins.*	*Deg.*	*Deg.*		
55.0	....	14.40	30,000	35,850	39,550	Unsatisfactory.		30.24	72	63	G.36	
54.0	....	17.12	30,000	35,330	38,850	......do......		30.24	72	63	G.36	
34.0	....	13.52	30,000	40,940	44,000	......do......		30.30	72	58	G.36	

J. PITMAN,
Major, Ordnance Department, U. S. A., President Board on Smokeless Powders.

FRANKFORD ARSENAL, *June 10, 1897.*

.45-caliber small arms, at Frankford Arsenal, Pa.

Mean variation in velocity.	Initial compression of cylinder per square inch.	Powder pressure per square inch.		Machine loading,—charges.		Barometer.	Thermometer.		Primer.	Remarks.
		Mean.	Extreme.	Extreme variation.	Mean variation.		Dry bulb.	Wet bulb.		
Ft. sec.	*Lbs.*	*Lbs.*	*Lbs.*	*Grs.*	*Grs.*	*Ins.*	*Deg.*	*Deg.*		
8.85	....	....	....	Unsatisfactory.		30.00	67	61	G.36	Velocities per second: Feet. Mean standard.. 1301.5 Mean variation standard....... 7.66 Extreme variation standard. 45.0 Pressure per square inch: Pounds. Mean standard.. 18,910 Extreme standard............. 19,940 Extreme of tests 26,300 The charge of 26.5 grains leaves a space of .4″ between the powder and the bullet. Stability: No trace in 103 minutes. Gravimetric density, .596. Granulation, 543,355 to the pound. Sieve test: +10, 0.1216%; +09, 0.1484%; +08, 9.4872%; +07, 73.3896%; +06, 15.2296%; +03, 1.6236%.
13.55	....	....	....			30.00	67	61	G.36	
7.07	....	....	....			30.27	63	54	G.36	
6.00	....	....	....			30.27	63	54	G.36	
11.85	....	....	....			30.27	63	54	G.36	
7.33	....	....	....			30.27	63	54	G.36	
17.16	18,000	19,940	22,550			30.00	67	61	G.36	
7.57	18,000	24,080	26,300			30.00	67	61	G.36	
7.25	18,000	18,395	19,250			30.27	62	54	G.36	
11.96	18,000	19,440	22,150			30.27	62	54	G.36	
9.48	18,000	Less than 18,000				30.27	62	54	G.36	
10.40	18,000	18,680	19,250			30.27	62	54	G.36	

Heat test, 130° F. 24 hours. Loss, 1.5023 per cent. Moisture in Hy'g, 24 hours. Gain, 1.3831 per cent. Temperature, 57°-72° F. Moisture and air in hy'g. 24 hours and in air 24 hours. Gain, 0.3843 per cent. Humidity, 61-72 per cent. Cartridges exposed to heat 24 hours; also to moisture 1 week. Specific gravity and residue from flash not taken, from lack of powder for tests.

Designation (including date of receipt, quantity, etc.) of lot or sample of powder tested: Weidig No. 2 smokeless powder for caliber .45 small arms. Received April 19, 1897.

J. PITMAN,
Major, Ordnance Department, U. S. A., President Board on Smokeless Powders.

FRANKFORD ARSENAL, *June 10, 1897.*

Record of tests of DuPont black, lot No. 3 powd

Date.	Gun.	Nature of test.	Powder charge. Kind.	Powder charge. Weight.	Bullet, kind and weight.	Shots fired.	Mean velocity at 53 feet from muzzle.	Variation velocity Ex-treme.	F st a
1897.				*Grains.*		*No.*	*Ft. sec.*	*Ft. sec.*	*Ft*
June 2	Springfield rifle, caliber .45. No. 248538.	Standard	DuPont black, lot No. 3.	69.0	Lead, .45 caliber, 500 grains.	10	1.287.4	16.5	....
June 2		Heat (cartridges)		69.0		10	1,229.2	101.0	–
June 2		Moisture (cartridges)		69.0		10	1,285.9	19.0	–
June 2		Heat (powder)		69.0		10	1,301.2	26.5	+
June 2		Moisture (powder)		69.0		10	1,221.3	19.0	–
June 2	Pressure gun, caliber .45. No. 2.	Standard		69.0		5	1,283.9	27.5	....
June 2		Heat (cartridges)		69.0		5	1,242.9	121.5	–
June 2		Moisture (cartridges)		69.0		5	1,208.8	64.0	–
June 2		Heat (powder)		69.0		5	1,299.9	29.5	+
June 2		Moisture (powder)		69.0		5	1,222.5	17.0	–

Designation (including date of receipt, quantity, etc.) of lot or sample of powder tested: Du black, lot No. 3.

.45 caliber small arms, at Frankford Arsenal, Pa.

Mean variation in velocity.	Initial compression of cylinder per square inch.	Powder pressure per square inch.		Machine loading charges.		Barometer.	Thermometer.		Primer, caliber.	Remarks.
		Mean.	Extreme.	Extreme variation.	Mean variation.		Dry bulb.	Wet bulb.		
Ft. sec.	*Lbs.*	*Lbs.*	*Lbs.*	*Grs.*	*Grs.*	*Ins.*	*Deg.*	*Deg.*		Velocities per second: Feet. Mean standard 1,287.4; Mean variation standard 4.22; Extreme variation standard 16.5. Pressure per square inch: Pounds. Mean standard 18,820; Extreme standard 18,820; Extreme of tests 26,500. Heat test, 24 hours, 130° F.; loss, 0.7283 per cent. Moisture test, 24 hours in Hygrs.; gain, 1.5658 per cent. Temperature, 63° to 71° F. Cartridges exposed to heat 24 hours; exposed to moisture 1 week.
4.22	......	......	......	......	......	30.23	72	62	.45	
29.40	......	......	......	......	......	30.18	75	62	.45	
4.20	......	......	......	......	......	30.18	75	62	.45	
5.88	......	......	......	......	......	29.99	71	66	.45	
5.58	......	......	......	......	......	29.99	71	66	.45	
9.92	18,000	18,820	20,800	......	......	30.23	72	62	.45	
45.32	18,000	18,210	18,400	......	......	30.18	75	62	.45	
18.36	18,000	Less than 18,000		......	......	30.18	75	62	.45	
7.68	18,000	24,240	26,500	......	......	29.99	71	66	.45	
4.80	18,000	Less than 18,000		......	......	29.99	71	66	.45	

J. PITMAN,
Major, Ordnance Department, U. S. A., President Board on Smokeless Powders.

FRANKFORD ARSENAL, *June 10, 1897.*

IV.—ROTT

[Sample furni

Respectfully returned to the commanding officer, Frankford Ars requirements, in that the standard velocity is not obtained wi
For the board:

NOTE.—Further reference to the tests of this powder is made i

Record of tests of sample of Rottweil smokeless p

Date.	Gun.	Nature of test.	Powder charge. Kind.	Powder charge. Weight.	Bullet, kind and weight.	Shots fired.	Mean velocity at 53 feet from muzzle.	Variation velocit Extreme.	
1896.				*Grains.*		*No.*	*Ft. sec.*	*Ft. sec.*	
Oct. 24	U. S. magazine rifle, No. 38127.	Standard	Sample lot of Rottweil smokeless powder. Received Oct. 22, 1896.	32.5	2.20 grains nickel steel.	20	1,904.6	94.0	...
Oct. 29		Standard (powder)		32.5		10	1,942.5	39.0	...
Oct. 29		Heat		32.5		10	2,032.6	82.0	
Oct. 29		Moisture		32.5		10	1,733.5	59.0	−
Oct. 29		Moisture and air		32.5		10	1,895.3	50.0	−
Oct. 29		Air exposure		32.5		10	1,912.9	32.0	−
Nov. 2		Standard (cartridges)		32.5		10	1,918.1	21.0	...
Nov. 2		Cold		32.5		10	1,870.8	34.0	−
Nov. 5		Standard (powder)		32.5		10	1,899.6	60.0	...
Nov. 5		Cold		32.5		10	1,888.3	75.0	−
Nov. 5		Standard (cartridges)		32.5		10	1,905.9	70.0	...
Nov. 5		Heat		32.5		10	1,971.1	81.0	+
Nov. 5		Moisture		32.5		10	1,893.9	32.0	−
Oct. 24	Pressure gun. 15	Standard		32.5		10	1,955.4	66.0	..
Oct. 29	16	Standard (powder)		32.5		10	1,940.1	42.0	...
Oct. 29	16	Heat		32.5		7	2,020.8	34.0	+
Oct. 29	16	Moisture		32.5		10	1,770.3	44.0	−
Oct. 29	16	Moisture and air		32.5		10	1,941.3	37.0	+
Oct. 29	16	Air exposure		32.5		10	1,953.6	24.0	+
Nov. 2	16	Standard (cartridges)		32.5		5	1,924.0	6.0	...
Nov. 2	16	Cold		32.5		5	1,881.8	36.0	−
Nov. 5	16	Standard (powder)		32.5		10	1,920.4	31.0	...
Nov. 5	16	Cold		32.5		10	1,911.1	72.0	−
Nov. 5	16	Standard (cartridges)		32.5		5	1,951.2	62.0	..
Nov. 5	16	Heat		32.5		4	1,986.5	54.0	+
Nov. 5	16	Moisture		32.5		5	1,914.0	62.0	−

OKELESS POWDER.

E. Kraftmeier.]

FRANKFORD ARSENAL, PA., *December 29, 1896.*

h report of test inclosed. This powder does not fulfill the ballistic
eeding the limit of pressure.

B. W. DUNN,
First Lieutenant, Ordnance Department, U. S. A., President.

ort of the chemical laboratory, dated September 9, 1897.

.30 caliber small arms, at Frankford Arsenal, Pa.

tial m-ee-1 of in-per are ch.	Powder pressure per square inch.		Machine loading,—charges.		Barometer.	Thermometer.		Primer.	Remarks.
	Mean.	Extreme.	Extreme variation.	Mean variation.		Dry bulb.	Wet bulb.		
bs.	*Lbs.*	*Lbs.*	*Grs.*	*Grs.*	*Ins.*	*Deg.*	*Deg.*		
....	....	....	......	......	29.70	55	49	G .36	Velocities per second: Feet. Mean standard .... 1,912.6 Mean variation standard .... 14.64 Extreme variation standard .... 94.0 Pressures per square inch: Pounds. Mean standard............ 38,451 Extreme standard .... 40,923 Extreme of tests 52,400
....	....	....	......	......	30.00	73	68	G .36	
....	....	....	......	......	30.30	73	68	G .36	
....	....	....	......	......	30.30	73	68	G .36	
....	....	....	......	......	30.30	73	68	G .36	
....	....	....	......	......	30.30	73	68	G .36	
....	....	....	......	......	30.27	72	58	G .36	
....	....	....	......	......	30.27	72	58	G .36	
....	....	....	......	......	29.70	68	68	G .36	
....	....	....	......	......	29.70	68	68	G .36	
....	....	....	......	......	29.65	68	68	G .36	
....	....	....	......	......	29.65	68	68	G .36	
....	....	....	......	......	29.65	68	68	G .36	
800	38,150	43,950	......	......	29.70	55	49	G .36	Stability. No trace in 190 minutes. Specific gravity, 1.6156. Gravimetric density, .744. The amount of smoke given off by this powder at each discharge is somewhat less than that given by the Du Pont and Peyton powders. The difference, however, is not a marked one. The amount of smoke is considerably less than that given by the W.-A. powder.
800	37,967	40,100	......	......	30.30	73	68	G .36	
800	50,040	52,400	......	......	30.33	68	64	G .36	
800	29,993	30,700	......	......	30.33	68	64	G .36	
800	37,248	40,566	......	......	30.30	73	68	G .36	
300	38,787	42,150	......	......	30.30	73	68	G .36	
300	37,163	38,866	......	......	30.27	72	58	G .36	
300	33,260	36,700	......	......	30.27	72	58	G .36	
350	38,643	41,933	......	......	29.70	68	68	G .36	
350	35,065	38,800	......	......	29.70	68	68	G .36	
750	40,923	45,233	......	......	29.65	68	68	G .36	
300	41,908	44,400	......	......	29.65	68	68	G .36	
300	35,220	37,100	......	......	29.65	68	68	G .36	

signation (including date of receipt, quantity, etc.) of lot or sample of powder tested: Sample lot
ttweil smokeless powder. Received October 22, 1896.

B. W. DUNN,
First Lieutenant, Ordnance Department, U. S. A.,
President of Board for the Inspection and Tests of Material.

ANKFORD ARSENAL, *December 28, 1896.*

(1871—Enc. 8)

V.

FRANKFORD ARSENAL,
Philadelphia, Pa., March 11, 1897.

SIR: The board for tests of contract powders has the honor to sub mit the following record of a test of Savage smokeless powder in th .30-caliber rifle.[1]

Sample Savage smokeless powder for caliber .30 rifle. March 6, 1897.

PRESSURE GUN NO. 21.

[Charge, 30 grains; 220 grains nickeled steel jacketed bullet.]

Velocity at 53 feet from muzzle.	Pressure, per square inch.	Remarks.
Feet per sec.	*Pounds.*	
1,811	31,100	Maximum pressure, 43,100 pounds; minimum pressure, 31,100 pounds. Velocity, extreme variation, 118 feet per second; mean variation, 24.40 feet per second. Barometer, 30''.28. Thermometer, dry bulb, 46°; wet bulb, 43°.
1,735	42,800	
1,853	38,350	
1,833	31,600	
1,773	43,100	
1,803	43,100	
1,789	36,850	
1,797	34,800	
1,818	33,500	
1,826	36,150	
Mean..1,803.8	37,135	

U. S. MAGAZINE RIFLE NO. 18647.

1,850	....	Velocity, extreme variation, 113 feet per second; mean variation, 35.50 feet per second. Barometer, 30''.28. Thermometer, dry bulb, 46°; wet bulb, 43°.
1,755	....	
1,786	....	
1,752	....	
1,737	....	
1,767	....	
1,818	....	
1,831	....	
1,835	....	
1,818	....	
Mean..1,794.9	....	

In view of the low velocity (1,795 feet per second) obtained with ε pressure of 37,000 pounds, and of the great irregularity of velocity anc pressure, the board recommends that no further test be made of thi powder.

Respectfully, for the board,

B. W. DUNN,
First Lieutenant, Ordnance Department, U. S. A., President.

The COMMANDING OFFICER, FRANKFORD ARSENAL, PA.

Approved and respectfully forwarded to the Chief of Ordnance United States Army, in connection with 2d indorsement on lette No. 11181—Enc. 4.

J. PITMAN,
Major, Ordnance Department, U. S. A., Commanding.

(11181—Enc. 5)

[1] In letter of February 27, 1897, the Savage Repeating Arms Company states: "Thi powder is not of American manufacture, although we generally carry in our maga zine here about 5 tons of the same. Preference for this powder is claimed because i contains no nitro-glycerine."

APPENDIX 14.

REPORT OF CHEMICAL LABORATORY AT FRANKFORD ARSENAL, PA., FOR PART OF THE YEAR ENDING JUNE 30, 1897.

FRANKFORD ARSENAL,
Philadelphia, Pa., September 9, 1897.

SIR: I have the honor to submit the following report of the principal operations at the chemical laboratory from July 1, 1896, to October 31, 1896:

The following powders were received:

CANNON.

1. Du Pont No. 2 A, 1896, for 3.2-inch rifle.
2. Maxim ⟨4⟩ No. 1 A, 1896, for 3.2-inch rifle.
3. Maxim, lot 2, 1896, for 3.2-inch rifle.
4. Maxim, for 3.2-inch rifle.
5. Maxim, for 3.2-inch rifle.
6. American Smokeless Powder Company, for 8-inch rifle.

SMALL ARMS, CALIBER .30.

Peyton, 1896, lots 1 to 10, 9,800 pounds, contract May 8, 1896.
Laflin & Rand W.-A, lots 1 to 5, 5,000 pounds, contract, May 8, 1896.
Du Pont, 1896, lots 1 to 5, 5,000 pounds, contract, May 8, 1896.
Rottweil, German (sample), received October 22, 1896.

The cannon powders were examined here only for stability, with the following results: No. 1, 38 to 39 minutes; No. 2, 40 minutes; No. 3, 56 to 65 minutes; No. 4, 45 to 69 minutes; No. 5, 22 to 37 minutes; No. 6, no trace in 190 minutes.

PEYTON POWDER.

From the California Powder Company, under contract May 8, 1896, 9,800 pounds were received July 9, 1896, and divided into nine lots of 1,000 pounds and one lot of 800 pounds.

These were examined and tested as described in my previous report (1894).

The general appearance of the grains is the same as that received under the former contract.

The granulation about 84,127.

Specific gravity varies from 1.6569 (10) to 1.6624 (11).

Gravimetric density varies from 1,005 (3) to 1,014.6 (10).

Residue, after flashing on glass plate, of lot 1, 1.79 per cent.

Stability above sixty minutes.

To obtain more uniform ballistic results the following variations in weight of charge were required in the different lots:

Charge 36.6 grains, lots 1, 3, 4, 5.
Charge 36.7 grains, lots 2, 6, 8, 9, 10.
Charge 36.8 grains, lot 7.

With the U. S. magazine rifle, caliber .30, a 220-grain cupro-nickel-steel jacketed bullet, $G_{.36}$ primer and the varying charge, the average velocities at 53 feet, average mean variation, and average pressures were:

Charge 36.6 grains: Velocity at 53 feet, 1,956.7 feet; muzzle velocity, 9.89 feet; pressure, 36,540 pounds per square inch.

Charge 36.7 grains: Velocity at 53 feet, 1,958.7 feet; muzzle velocity, 9.40 feet; pressure, 37,397 pounds per square inch.

Charge 36.8 grains: Velocity at 53 feet, 1,960.6 feet; muzzle velocity, 9.80 feet; pressure, 39,032 pounds per square inch.

The effect of the various tests on the powder and cartridges is shown in the following table:

PEYTON—LOTS 1 TO 10.

[The figures in parentheses refer to the number of the lot.]

Test.		Lots.	Change in velocity.		
			Maximum.	Mean.	Minimum.
			Ft. sec.	*Ft. sec.*	*Ft. sec.*
Heat, 130° F. for 24 hours	Powder		+ 29.3 (9)	+ 9.1	+ 3.2 (2)
	do	5, 8	— 12.6 (8)		— 3.2 (5)
	Cartridges		+106.4 (4)	+ 65.2	+ 24.4 (7)
Moisture	Powder		—156.7 (1)	—107.	—66.8 (10)
Saturated atmosphere 24 hours	Cartridges		— 40.5 (7)	— 18.7	— 2.4 (1)
	do	2	+ 8.9 (2)		
Moisture and air as above and 24 hours to air	Powder		— 42.4 (6)	— 21.7	— 11.6 (4)
	do	9, 10	+10.0 (10)		— 5.3 (9)
Air 24 hours	do	1, 2, 3, 6, 7, 8	— 20.6 (8)	— 13.6	— 0.8 (6)
	do	4, 5, 9, 10	— 13.7 (9)	+ 5.1	+ 0.6 (3)
Cold and air	do	1	+ 1.2 (1)		
Cold	Cartridges	1	— 86.9		

Test.		Lots.	Change in pressure per square inch.			Change in weight per cent.
			Maximum.	Mean.	Minimum.	
			Pounds.	*Lbs.*	*Pounds.*	
Heat, 130° F. for 24 hours.	Powder	2, 4, 5, 6, 8	+ 1,793 (6)	+ 689	+ 220 (4)	Lost 0.363.
	do	1, 3, 7, 9, 10	— 3,415 (9)	—2,136	— 314 (10)	
	Cartridges	1 to 10	+10,656 (6)	+6,623	+2,210 (1)	
Moisture	Powder		— 9,888 (1)	—5,906	—4,210 (9)	Gained 1.354.
Saturated atmosphere 24 hours.	Cartridges		— 5,564 (4)	—3,019	—1,456 (2)	
	do	1, 8	+ 2,340 (1)		+ 284 (8)	
Moisture and air as above and 24 hours to air.	Powder		— 4,217 (1)	—2,419	— 705 (9)	Gained 0.119.
	do	4, 7, 10	— 432 (7)	+ 228	+ 1 (4)	
Air 24 hours	do		— 3,126 (3)	—1,734	— 581 (4)	Gained 0.088.
	do	9, 10	+1,114 (10)		+ 382 (9)	
Cold and air	do	1	— 2,332 (1)			Gained 0.022.
Cold	Cartridges	1	— 7,457			

LAFLIN & RAND (W.-A.) POWDER.

This powder is similar in form to that described in my last report, but is of a light lemon color.

Five thousand pounds were received from the American Smokeless Powder Company, under contract of May 8, 1896, on September 2, 1896, and divided into five lots for examination and inspection.

Granulation about 135,000.

Specific gravity varies from 1.773 (5) to 1,781 (1).

Gravimetric density varies from 978 (1) to 996 (3).

Residue remaining after flashing, 8.12 per cent.

Stability above twenty-five minutes.

To obtain the required velocity, the weight of charge was varied with each lot. The velocities are as follows:

Charge, 40 grains, lot 1: Velocity at 53 feet, 1,967.5 feet; muzzle velocity, 6.9 feet; pressure, 37,175 pounds per square inch.

Charge, 39 grains, lot 2: Velocity at 53 feet, 1,963 feet; muzzle velocity, 5.76 feet; pressure, 36,516 pounds per square inch.

Charge, 39.2 grains, lot 3: Velocity at 53 feet, 1,964 feet; muzzle velocity, 4.4 feet; pressure, 34,086 pounds per square inch.

Charge, 38.5 grains, lot 4: Velocity at 53 feet, 1,964.2 feet; muzzle velocity, 3.9 feet; pressure, 37,444 pounds per square inch.

Charge, 38 grains, lot 5: Velocity at 53 feet, 1,965 feet; muzzle velocity, 6.2 feet; pressure, 34,778 pounds per square inch.

The effect of the various tests on powder and cartridges is shown in the following tables:

LAFLIN & RAND (W.-A.) LOTS 1 TO 5.

[The figures in parentheses refer to the number of the lot.]

Test.		Lots.	Change in velocity.		
			Maximum.	Mean.	Minimum.
			Ft. sec.	*Ft. sec.*	*Ft. sec.*
Heat	Powder	1, 5	+ 64.1 (1)	+ 24.3	+ 2.6 (5)
	Cartridges		+ 74.2 (2)	+ 40.6	+23.0 (3)
Moisture	Powder		—163.4 (5)	—115.7	—94.6 (2)
	Cartridges		— 20.0 (3)	— 66.6	0 (1)
Moisture and air	Powder	2, 3, 5	— 16.3 (2)	— 9.9	— 4.8 (3)
	do	1, 4	+ 17.6 (1)		+ 7.2 (4)
Air	do		+ 15.6 (1)	+ 8.7	+ 2.6 (2)
	do	4, 5	— 9.8 (5)		— 2.8 (4)
Cold and air	do	1	+ 6.4 (1)		
Cold, 140° F., for six hours	Cartridges	1	— 32.1 (1)		

Test.		Lots.	Change in pressure per square inch.			Change in weight per cent.
			Maximum.	Mean.	Minimum.	
			Pounds.	*Pounds.*	*Pounds.*	
Heat	Powder	1, 2, 3, 5	+4,210 (3)	+2,731	+1,099 (2)	Lost from 0.218 (3) to 0.760 (1).
		4	—2,723			
	Cartridges		+7,913 (2)	+4,962	+1,587 (1)	
Moisture	Powder		—8,129 (4)	—4,822	—2,825 (5)	Gained 1.952 (1) to 1.647 (5).
	Cartridges		—2,993 (2)	—1,638	— 787 (4)	
Moisture and air	Powder	3, 4, 5	— 819 (4)	— 578	— 147 (5)	Gained 0.275 (1) to 0.053 (4).
	do	1, 2	+1,979 (2)		+1,447 (1)	
Air	do	2	+2,567 (2)			Gained 0.159 (2) to 0.038 (3).
	do		+1,593 (4)	— 813	89 (1)	
Cold and air	do		+1,683 (1)			Lost 0.194.
Cold, 140° F., for six hours.	Cartridges		—1,533 (6)			

DU PONT (1896) POWDER.

Under contract of May 8, 1896, 5,000 pounds were received from Du Pont & Co., August 26, 1896, and divided into five lots. It is similar in appearance to that received under previous contract.

Specific gravity varies from 1.6382 (5) to 1.6462 (4).

Gravimetric density varies from 959 (1) to 972 (5).

Residue remaining after flashing, 2.9 per cent.

Stability above 40 minutes.

The following charges were required in the various lots to obtain the required velocity, etc.:

Charge, 38.5 grains, lots 1 and 5: Velocity at 53 feet, 1,963.6 feet; muzzle velocity, 6.35 feet; pressure, 38,593 pounds per square inch.

Charge, 38.3 grains, lots 3 and 4: Velocity at 53 feet, 1,963.8 feet; muzzle velocity, 8.40 feet; pressure, 36,837 pounds per square inch.

Charge, 39 grains, lot 2: Velocity at 53 feet, 1,968.6 feet; muzzle velocity, 8.52 feet; pressure, 38,101 pounds per square inch.

The effect of the various tests on this powder and cartridges is shown in the following table:

DU PONT—LOTS 1 TO 5.

[The figures in parentheses refer to the number of the lot.]

Test.		Lots.	Change in velocity.		
			Maximum.	Mean.	Minimum.
			Ft. sec.	*Ft. sec.*	*Ft. sec.*
Heat	Powder		+ 32.4 (2)	+ 19.6	+ 4.2 (4)
	do				
	Cartridges		+ 83 (5)	+ 68.6	+ 55.8 (1)
Moisture	Powder		—139 (3)	—128.1	—110.8 (1)
	Cartridges		— 22.2 (3)	— 13.1	— 7.8 (5)
	Cartridges	1	+ 1.9 (1)		
Moisture and air	Powder		— 28.5 (5)	— 13.1	— 7 (3)
Air	do		— 21 (2)	— 10.5	— 3 (3)
	do	1, 5	+ 1.4 (5)		+ .2 (1)
Cold and air	do	1	— 12.4 (1)		
Cold	Cartridges	1	— 18.6 (1)		

Test.		Lots.	Change in pressure per square inch.			Change in weight, per cent.
			Maximum.	Mean.	Minimum.	
			Pounds.	*Pounds.*	*Pounds.*	
Heat	Powder	2, 5	+2,467 (2)		+1,865 (5)	Lost from 0.556 (1) to 0.465 (2).
	do	1, 3, 4	—2,795 (1)	—2,079	— 973 (4)	
	Cartridges		+9,867 (2)	+6,309	+4,393 (5)	
Moisture	Powder		—9,791 (1)	—7,967	—6,920 (5)	Gained from 1.419 (5) to 1.123 (2).
	Cartridges		—4,576 (1)	—3,113	—2,193 (5)	
	Cartridges	2, 3	+ 713 (3)		+ 297 (2)	
Moisture and air	Powder		—4,168 (5)	—2,876	—1,991 (3)	Gained from 0.285 (5) to 0.085 (1).
Air	do		—1,765 (2)	—1,078	— 638 (3)	Gained from 0.069 (4) to 0.067 (3).
	do	5	+3,521 (5)			
Cold and air	do	1	+1,593 (1)			Lost 0.025 (1).
Cold	Cartridges	1	+2,680 (1)			

ROTTWEIL POWDER.

A sample of this powder was received from the Ordnance Office October 22, 1896.

It is of a dark color and in the form of square plates, having a specific gravity of 1.615 and a gravimetric density of 744.

Stability good, as there was no discoloration of the test paper after one hour's exposure.

A velocity (at 53 feet) of 1,942.5 feet, with a mean variation of 8.8 feet, was obtained with a charge of 32.5 grains in the U. S. magazine rifle, caliber .30. Pressure, 37,966 pounds per square inch.

The heat test caused an increase of 80.7 feet velocity and 12,073 pounds pressure and a loss in weight of 0.16 per cent.

With cartridges having a temperature of about 130° F. the increase in velocity was 53.3 feet and in pressure 985 pounds.

Test.		Velocity (at 53 feet) lost.	Pressure lost.	Change in weight, per cent.
		Feet.	*Pounds.*	
Moisture		168.8	7,973	Gained 1.649.
	Cartridges	37.2	5,708	
Moisture and air	Powder	52.2	1,718	Gained 0.065.
Air	do	29.6	180	Lost 0.156.
Cold and air	do	11.3	3,579	Gained 0.154.
Cold	Cartridges	47.3	4,903	

The year's exposure of loaded cartridges on the roof of the chemical laboratory was completed October 1, 1896. Every three months cartridges were removed and examined for velocity, stability, and per cent of moisture in charge.

The results of each examination are given, so that continuous effect may be noted.

Cartridges loaded with the following powders:

Du Pont, received July 10, 1895; contract, 1895;
Peyton, received July 18, 1895; contract, May 31, 1895;
Leonard, W.-A., received July 19, 1895; contract, June 3, 1895,

were thus exposed and the results compared with similar cartridges loaded at the same time and retained in the chemical laboratory, in the original pasteboard boxes, as a standard.

Many of the cases were cracked (principally in the neck) by the exposure and all injured when fired. None of the standard cases were injured. The interior of the cases was not affected by the contact of the powder. Neither was the primer injured by the exposure to the weather. The average of five shots each, using exposed and standard primers, a new cartridge case, and powder from the laboratory magazine, gave, respectively, 1,918 and 1,904 feet instrumental velocity.

In order to ascertain whether the ballistic properties of the powder had been permanently injured by the exposure, the powders which had been dried at 130° F. for twenty-four hours (heat test), both exposed and standard, were fired for velocity and pressure.

Roof exposure; exposed October 1, 1895.

DU PONT POWDER.

Date of removal.	Exposed.			130° F. for 24 hours.		Standard.			130° F. for 24 hours.		Change from standard.	
	Velocity.	Stability.	Moisture.	Velocity.	Pressure.	Velocity.	Stability.	Moisture.	Velocity.	Pressure.	Velocity.	Moisture.
1896.	*Ft. sec.*	*Minutes.*	*Per cent.*	*Ft. sec.*	*Pounds.*	*Ft. sec.*	*Minutes.*	*Per cent.*	*Ft. sec.*	*Pounds.*	*Ft. sec.*	*Per cent.*
						1,965	15 to 16	0.3866				
Jan. 1	1,777.9	30 to 33	1.5869			1,957.4	30 to 33	0.4851			—179.5	+0.1018
Apr. 1	1,887.4	28 to 31	0.5206			1,966	36 to 41	0.4649			— 78.6	+0.0557
July 1	1,861.2	57 to 57	0.7916			1,971.2	24 to 24	0.4305			—110	+0.3611
Oct. 1	1,833.3	39 to 39	1.0292	1.926	34.000	1,949.8	25 to 31	0.7735	1,935	34,000	—116.5	+0.2557

PEYTON POWDER.

Date of removal.	Velocity.	Stability.	Moisture.	Velocity.	Pressure.	Velocity.	Stability.	Moisture.	Velocity.	Pressure.	Velocity.	Moisture.
						1,949	20 to 27	0.5463				
Jan. 1	1,759.8	14 to 16	1.9758			1,945.9	43 to 43	0.6546			—186.1	+1.3212
Apr. 1	1,858.9	33 to 33	0.6959			1,966.4	49 to 51	0.6902			—107.5	+0.0057
July 1	1,756.5	53 to 53	0.7261			1,905.2	28 to 38	0.5726			—148.7	+0.1535
Oct. 1	1,887.5	35 to 35	1.3648	1,969	42,000	1,922	39 to 39	1.0239	1,984	43,000	— 34.5	+0.3409

LEONARD W.-A. POWDER.

Date of removal.	Velocity.	Stability.	Moisture.	Velocity.	Pressure.	Velocity.	Stability.	Moisture.	Velocity.	Pressure.	Velocity.	Moisture.
						1,949	20 to 27	0.5463				
Jan. 1	1,831.6	56 to 60	2.1146			1,946.8	56	0.6948			—115.2	+1.4198
Apr. 1	1,946.8	73 to 73	1.4161			1,954.4	73 to 73	0.5912			— 7.6	+0.8249
July 1	1,965.2	42 to 60	1.0561			1,972.8	Above 109	0.6210			— 7.3	+0.4361
Oct. 1	1,975.1	14 to 18	Lost.	2,014	37,400	1,969.8	99 to 99	Lost.	2,092	47.000	+ 5.8	Lost.

The powder, in open glass dishes, was exposed under glass to the direct rays of the sun for one year.

The general effect was to reduce the stability, decrease the weight by evaporation of some of the ingredients, and change the ballistic properties. The three contract powders were treated in this manner.

Du Pont, stability from sixteen minutes to one and one-half minutes. Lost 12.97 per cent in weight. Velocity reduced to about 1,800 feet with 30,000 pounds pressure.

The powder became very much caked, the granulation in some places entirely disappearing, so that portions resembled scoria, and the glass was covered with a yellow substance.

Peyton, stability from twenty-seven to two minutes. Lost 14.97 per cent in weight. Velocity reduced to 1,676 feet with a pressure below 29,000 pounds.

Many of the grains turned yellow in color, and the glass was covered with a yellowish film. Very slightly caked.

Leonard W.-A., stability, after an exposure of nine months, reduced from forty to two minutes. Lost in weight, 3.13 per cent. Velocity, 1,492 feet with a pressure of 33,000 pounds. Granulation and appearance of powder not changed.

Respectfully submitted.

J. PITMAN,
Major, Ordnance Department, U. S. A.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

(Through the Commanding Officer, Frankford Arsenal.)

Approved, and respectfully forwarded to the Chief of Ordnance, United States Army, in compliance with instructions of July 13, 1897.

J. M. WHITTEMORE,
Colonel, Ordnance Department, U. S. A., Commanding.

(10584—Enc. 6)

Appendix 15.

RELOADING TOOLS FOR 1.65-INCH HOTCHKISS MOUNTAIN GUN, AS MADE AT THE FRANKFORD ARSENAL, PA.

(3 plates.)

NOMENCLATURE.

[Frankford Arsenal drawing, dated September 28, 1897.]

(1) Loading and neck resizing press; (2) loading sleeve; (3) common shell plunger; (4) canister plunger; (5) cartridge ejector; (6) case ejector; (7) neck resizing die; (8) screw end cap for resizing; (9) venting punch; (10) fuse wrench; (11) fuse seat wiping brush; (12) shell charger; (13) cartridge-case charger; (14) shell funnel; (15) cartridge-case funnel.[1]

INSTRUCTIONS.

The reloading tools are supplied in sets and should not be carried into the field under ordinary circumstances. For loading this ammunition there should be a suitable room containing a heavy table or a work bench to which the loading press is secured, in a vertical or in a horizontal position, as most convenient.

If a fired case can not be readily inserted into the chamber of gun, after the neck has been resized, the case should be rejected.

To resize neck of case.—The cases after firing are to be thoroughly cleaned with warm soapsuds (using a brush, rag on a stick, or some other device to remove the residue), rinsed with hot water and dried.

If, on blowing through the case from the front end, an escape of air should not be perceptible at the vent in the base, the venting punch is used by inserting it in the vent from the exterior and giving it a slight blow.

Oil the interior of neck resizing die and the exterior of neck of case.

Insert the die in its slotted seat in middle of press, the lettered face toward the screw; place the screw end cap over base of case and place the case in position, with the end of screw properly centered in outer recess in cap. (See photograph No. 1.) Force the neck into die by advancing the screw as far as possible, i. e., until the fixed ring on screw comes into contact with the end of press. Slacken the screw, remove cap, reverse the case and die, insert case ejector, and advance screw until the case can be pulled out of the die by hand. (See photograph No. 2.)

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[1] These tools differ from the Hotchkiss loading tools, described on page 14 of the pamphlet entitled, "Handbook of the Hotchkiss 2-pounder Mountain Gun, London, 1894," in the following particulars: The loading press has a neck resizing attachment with additional implements, comprising (6) case ejector, (7) neck resizing die, and (8) screw end cap for resizing. The venting punch (9) is also additional. The remaining tools are of equal number and serve the same purposes in the two "sets," but differ in certain dimensions. Whence the Hotchkiss tools can not be used for Frankford Arsenal ammunition. But the Frankford Arsenal tools complete may be used for reloading the Hotchkiss ammunition as well as that made at the Arsenal.

When new cases are used it will not be necessary to resize the necks.

To charge the shell.—Fill the shell charger with "small-arms powder" and level off with a straightedge (charge $1\frac{1}{2}$ ounces). Insert the shell funnel in the fuse hole and pour in the charge, at the same time tapping the side of the shell with a light wooden mallet. Remove all grains of powder from the screw thread of the fuse hole by means of the brush wiper. Brush the thread of the fuse stock, insert the fuse and screw it thoroughly home with the wrench. Should it require more force than can be applied to the wrench by hand, reject the fuse.

Never strike a fuse or attempt to force it.

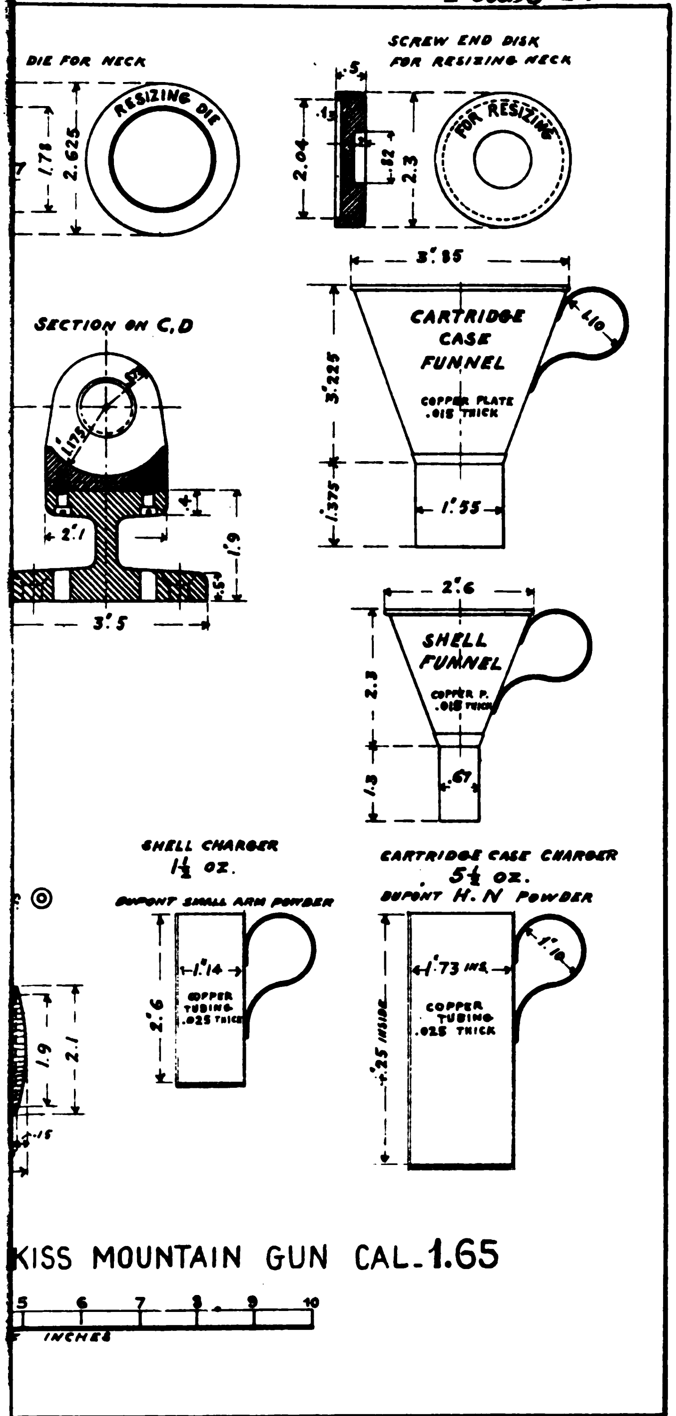
To fill the case.—Fill the cartridge case charger with Du Pont H N powder, and level off with a straightedge. Stand the case upright, insert funnel in mouth of case, and pour in the charge, tapping the side of the case with the flat of the hand to settle the powder. Insert the wad and press down by hand as far as possible.

To assemble the cartridge.—Oil lightly the body of the projectile in rear of band and center it in mouth of case. Slip the sleeve (grooved end upward) vertically over the projectile and case, holding it vertically and supporting the base of case with the hand; place the sleeve in the press (projectile pointing to the screw), insert the proper plunger and compress by means of the screw until the flange of the plunger comes into contact with the face of the sleeve. Slacken the screw, remove the sleeve and plunger from the press, holding the base of cartridge in the left hand. If the cartridge does not drop out when the sleeve is held vertically insert the cartridge ejector and press it out.

Never strike the ejector.

(21990—Enc. 8)

Plate I.



Appendix 15, 1897.

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APPENDIX 16.

REPORT OF PRINCIPAL OPERATIONS AT WATERVLIET ARSENAL FOR THE FISCAL YEAR ENDING JUNE 30, 1897.

(4 plates.)

SIR: I have the honor to submit herewith my report of the principal operations at this arsenal during the fiscal year.

ISAAC ARNOLD, Jr.,
Lieutenant-Colonel, Ordnance Department, U. S. A., Commanding.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

GUN CONSTRUCTION.

During the fiscal year work on gun construction has progressed steadily, satisfactorily, and as rapidly as the delivery of the forgings by the contractors would permit. The appropriation made by Congress for finishing and assembling seacoast guns, and which became available about the beginning of the fiscal year, made it possible to increase the force of employees in the large gun shop to nearly its full capacity for day work and to add a small night force. This latter force has not exceeded forty machinists, the endeavor being to expedite the work and increase the output by working the night shift upon those operations which require considerable time for their completion. The use of two shifts has continued throughout the year with most satisfactory results.

During the year considerable difficulty has been experienced in securing suitable bronze castings for breech plates and trays. Numerous castings delivered by contractors have been rejected and the work consequently delayed, with the result that some guns which otherwise would have formed part of the completed product of the year are incomplete, lacking breech plates and trays. In guns of the new design no breech plates are required, and the difficulty with the trays will be avoided by the use of cast steel.

In the latter half of the year work in the gun shop has been much delayed, the proper succession of operations interfered with, and the yearly output materially affected by the failure of the contractors to furnish forgings as rapidly as required. So noticeable did this become, that toward the close of the year the entire hoop, tube, and jacket departments had not a single forging in hand; and in an establishment like the gun shop, where the capacities of the various departments are so nicely adjusted, such a period of idleness in one department must in time be felt throughout the entire shop, and is practically equivalent to a complete shut down for a like period. In spite, however, of the difficulties and delays above mentioned, the output for the year, as given below, is much greater than that of any previous year, and is very gratifying.

In the seacoast gun department the number of guns finished during the year was as follows: Thirteen 8-inch, twenty-two 10-inch, and seventeen 12-inch. To obtain the output for the year the amount of work on guns in hand and unfinished at the beginning and end of the fiscal

year should be taken into consideration. Doing this, the output for the year is as follows: 6.65 8-inch guns, 21.2 10-inch guns, 19.9 12-inch guns, and 7.35 12-inch mortars, or a total output of 55.1 heavy guns, being about 50 per cent more than the output for any preceding fiscal year. The tonnage output for the year was 1,876 tons of heavy guns, an increase of 61 per cent over the largest output of preceding years.

In the small gun shop the six 7-inch B. L. siege mortars unfinished at the close of the last fiscal year were soon completed. The shop was then without work for several months. In December orders were received for the manufacture of thirty 3.2-inch B. L. rifles, ten 5-inch B. L. siege rifles, ten 7-inch B. L. siege howitzers, and twenty 7-inch B. L. siege mortars, but the first forgings for these guns were not delivered until the middle of March. The 3.2-inch guns were then taken in hand; six have been finished and the other twenty-four are well advanced. At the close of the year forgings for five 5-inch rifles, five 7-inch howitzers, and four 7-inch mortars had been delivered. All of them were taken in hand as soon as received, and they are as well advanced as the date of the receipt of the forgings would permit.

Two 5-inch R. F. rifles (L. 45) were taken in hand during the year. One, a built-up gun, with Driggs-Schroeder mechanism, is nearly completed; the other, a single-forging gun, is ready for its breech mechanism.

In addition to the above, one 4.7-inch Hotchkiss rifle has been fitted with a breech piece for the Gerdom breech mechanism. A defective trunnion on a 5-inch B. L. rifle made here in previous years has been removed and a new hoop substituted. Fifty-four sets of parts of the device for locking breechblock to tray for 8-inch, 10-inch, and 12-inch service rifles have been manufactured and issued. Two concentricity gauges for 12-inch mortars and various gauges, templets, and inspecting instruments for the use of inspectors at other establishments have been made. Numerous smaller parts of breech mechanism for different guns have been fabricated as ordered.

The shops are now provided with a complete outfit of jigs, standard templets, and gauges to insure accuracy of finish and interchangeability of the various parts of the service guns. These, with the system of inspection of the parts now adopted, give a degree of accuracy to the finished work upon which, it is believed, it would be difficult to improve.

THE LOWER SHOPS.

The carpenter shop, the blacksmith shop, and the machine shop east of the canal have been run uninterruptedly during the year by the water power, with the exception of a few weeks occupied in the repairs of the canal by the State, during which period these shops were satisfactorily operated by electrical connection with the gun shops and the temporary conversion of an electric-light dynamo into a motor. These shops have been utilized, as heretofore, in connection with the electric plant, the increase and improvement of the water-supply system, the repair and construction work of the arsenal and gun plant, and, in addition, work has been performed of which the following is a summary:

598 8-inch, 10-inch, and 12-inch projectiles have been banded, painted, and boxed, ready for issue.

85 armament chests have been manufactured for 5-inch and 7-inch B. L. siege guns, and 8-inch, 10-inch, and 12-inch B. L. rifles, and 12-inch B. L. mortars.

60 sets of tools and implements for 5-inch and 7-inch B. L. siege guns and carriages, and 8-inch, 10-inch, and 12-inch B. L. rifles, and 12-inch B. L. mortars have been manufactured or completed.

2 pent houses have been manufactured for 8-inch and 10-inch B. L. rifles mounted on depressing carriages.

580 shells for field and siege rifles have been prepared for issue.
140 gas-check pads of various calibers have been manufactured. Articles for the filling of current orders for supplies have been manufactured, and sixty 8-inch, 10-inch, and 12-inch B. L. rifles and mechanisms have been lagged and boxed and shipped during the year, and fifteen additional seacoast rifles are ready for shipment at the present writing.

A material reduction has been made in the cost of some of these items during the past few months, especially in the armament chests, and it is expected that a further and satisfactory saving in the cost of the tools and implements can be effected during the ensuing year.

BUILDINGS, PLANT, AND OTHER CONSTRUCTION WORK—GUN FACTORY.

The equipment of the south wing for the finishing and assembling of 16-inch B. L. rifles has been completed. All four of the gun lathes, which were in process of erection last year, were, upon completion, carefully inspected, and some work on 12-inch guns and jackets has been done in them to test the efficiency of all the moving parts. The machines have all worked in a very satisfactory manner, and there is no doubt that they will work equally as well on the far heavier 16-inch work for which they were designed.

All shafting, belting, and friction clutches for these lathes have been completed and successfully operated.

A new interior cylinder for the shrinkage furnace has been substituted this year for the one which was put in last year, the apparently short life of this cylinder being due to the large number of jackets and C hoops heated in this furnace during the year. A new cast-iron extension has been made for this furnace to adapt it for the long jackets for 12-inch rifles, model 1895.

The height of the hoop furnace has been increased by 30 inches in order to be able to heat 12-inch D hoops and 10-inch C and D hoops of guns, model 1895, thus relieving the jacket furnace to a great extent. The bottom of this hoop furnace has been renewed once during the year. The working of these furnaces has been very satisfactory.

An experimental oil furnace has been constructed during the year, with a view of obtaining some data and experience in this line before proceeding with the construction of one large enough for 16-inch guns. The results so far have been satisfactory, but as the furnace is yet in its experimental stage, no definite report can be made at this time.

The east craneway for the 60-ton and 120-ton electric cranes has been extended one bay (18 feet) to the north, in order to make room for the 60-ton crane so as to enable the 120-ton crane to be placed over the shrinkage pit and handle the 16-inch gun.

The jacket lathes in the south wing have been lengthened so as to give them the necessary capacity for jackets for 12-inch guns, model 1895. A trolley rail with differential hoist has also been placed over these lathes in the proper position, so as to be able to hoist the heavy cutter heads and take them in and out of the boring bars conveniently.

An attachment for grinding large cutter heads and the long conical reamers for forcing slopes has been constructed and attached to a 42-inch lathe in the east aisle of the north wing. This work was formerly done in the small shop and caused a great deal of inconvenience to the work in that shop.

The second section of the small gun shop is being prepared for the installation of four 36-inch, two 30-inch, and six 16-inch lathes, specially designed and adapted for work on field and siege guns. A special overhead trolley arrangement for the easy handling of such guns is also under construction.

WATER POWER PLANT, ELECTRIC LIGHT AND POWER PLANT.

The water power plant, as described in a previous report, has be in successful operation during the past year. It has been necessary several occasions to run the lower shops by means of electricity fro the gun shop on account of freshets and the withdrawal of water fro the Erie Canal by the State authorities. It has been found to be bo safe and economical to run the lower shops by this means when t water power plant is out of action.

In order to increase the motor capacity, arrangements have been ma whereby both generators at the lower station can be operated as moto simultaneously, giving a capacity sufficient to run the pumps and a the machinery in the lower shops at the same time.

The electric light and power plants have been operated this year wit very satisfactory results, very little repair having been necessary. Th electric motor for the main hoist of the 60-ton crane has on several occa sions become overheated, destroying the insulation and causing sho circuits; this is due to the great strain on this motor in having to hoi or lower a 12-inch gun, the whole weight being applied suddenly, thu not giving the motor an opportunity for a gradual increase of speed an power. This motor is now being repaired.

Another year's experience has taught the absolute necessity of pr viding the inclosures mentioned in my last report for the electric ligh and pumping stations. The estimated cost of this work is about $60(

WATER SUPPLY.

The new water tower, with its equipments, has been in successful ope ation during the year. A new tank and a supplementary 5-inch distri uting main have been installed. The connection of the 5-inch force pip with the 6-inch distributing main lying north and east of the lowe shops, as recommended by me in my last report, has been made, an the following advantages have now been obtained: The post can no be supplied by means of the 6-inch and 8-inch distributing mains i case of accident or repair to the 5-inch force main; also, in case of fir the pumps can force water through the 5-inch force main and 6-inc and 8-inch distributing pipes at the same time. The complete syste of force mains and distributing pipes is shown on pl. 1.

FIRE PROTECTION.

In order to fully protect the gun-factory buildings, a new 6-inch pip was laid and a number of hydrants placed around the entire south en of the large gun shop (the north end being previously well protecte by outside hydrants). The location of these hydrants is shown in pl. This new pipe is connected with the 8-inch distributing main.

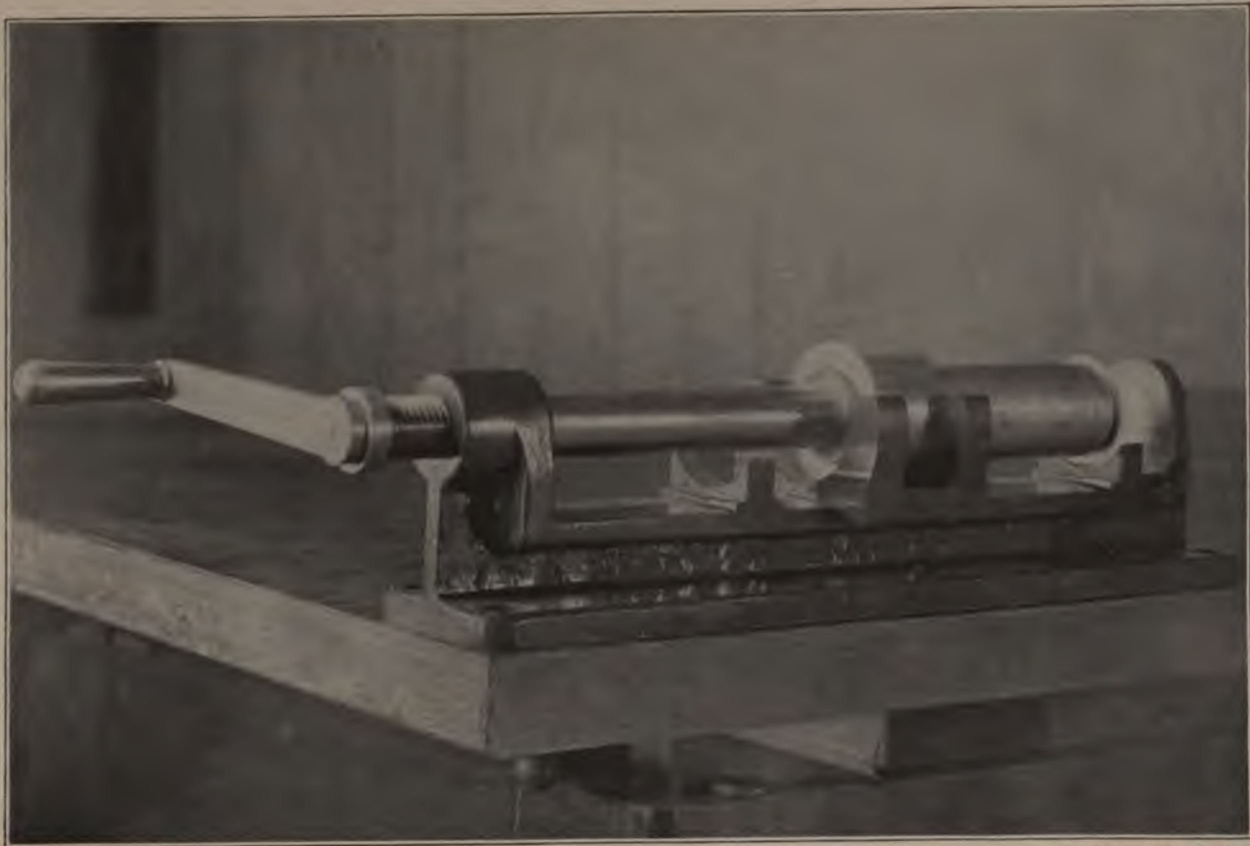
For the inside protection of the gun shop a complete circuit of 4-inc water pipe has been laid; to this pipe is connected twenty-six 3-inc valves, equally distributed around the shop; to each of these valve there is connected 50 feet of fire hose with nozzles attached, the hos being arranged on stationary hose racks, so that, in case of fire in an part of the shop, a stream of water can be applied almost immediatel The arrangement of this inside system is shown in pls. 3 and 4.

ISAAC ARNOLD, Jr.,
Lieutenant-Colonel, Ordnance Department, U. S. A., Commanding.

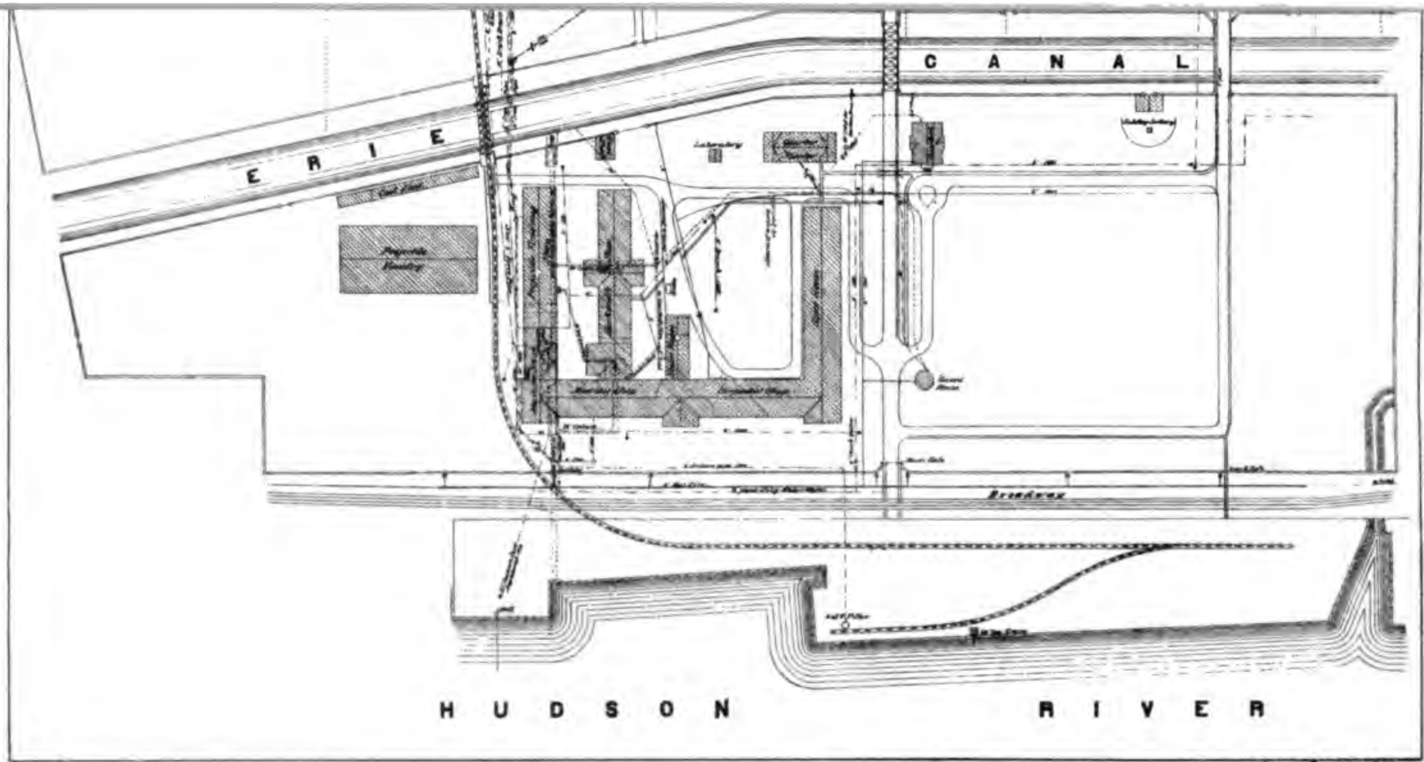
WATERVLIET ARSENAL, *September 3, 1897.*

(10104—Enc. 34)

PLATE III.



Appendix 15, 1897.



September 16, 1897.

Ord 55 2

APPENDIX 17.

REPORT OF PRINCIPAL OPERATIONS AT WATERTOWN ARSENAL FOR THE YEAR ENDING JUNE 30, 1897.

WATERTOWN ARSENAL, MASS., *August 28, 1897.*

SIR: I have the honor to forward herewith my report of the principal operations at this arsenal for the past fiscal year.

Very respectfully, your obedient servant,

J. W. REILLY,
Major, Ordnance Department, U. S. A., Commanding.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

The principal operations at this arsenal since my last annual report have been as follows: In the enlargement and improvement of the gun-carriage plant, the fabrication of gun carriages for permanent fortifications and gun carriages and platforms for field and siege purposes, the manufacture of templets for setting base plates of gun carriages, testing tools and gauges for inspecting officers, castings for other arsenals and for Sandy Hook Proving Ground, cast-iron shot and shell, machines for mechanical maneuvers, implements for the service of guns, in the improvement and care of buildings and grounds, and in the improvement and enlargement of the testing department.

Aside from the purchase of some small drills, bench lathes, improved grindstones, vises, etc., the principal addition to the manufacturing plant has been the purchase and erection of an iron planer 12 feet 2 inches by 10 feet by 25 feet. This tool, by its capacity, stiffness, and accuracy, enables us not only to do work we could not do before, but does it so quickly and well that it serves as a check upon the other planers, which, being light, became damaged and incorrect by the heavy service imposed upon them.

When five years ago the enlargement and improvement of the gun-carriage plant was inaugurated, among the machine tools on hand some few planers, lathes, horizontal boring mills, shapers, and slotters were still serviceable and were retained and enumerated among the list of machine tools of the new plant. These since then, by work on steel castings and forgings, have become worn out and need to be all replaced by new, larger, and more improved tools. The next fiscal year there will be an appropriation of $15,000 available for this purpose, but this amount will not procure half of the needed tools.

MANUFACTURES.

The shops have been very busily employed during the year, and for several months of the year were running sixteen hours per day upon the more important tools. It would not be expedient, if it were possible, to complete all orders on hand at the end of the year. To keep

the shops continuously employed work orders interlap; new ones are started while old ones are toward completion. The year's progress report therefore shows the completion of orders left over from the preceding year, the commencement and completion of others, and the commencement of new orders.

My last report showed that work was commenced and partially completed on one 10-inch disappearing carriage, model 1894, six 12-inch mortar carriages, two 15-inch altered smoothbore carriages, and six 7-inch siege mortar carriages. These were fully completed early in the year.

In addition the following orders were commenced and completed entire during the year: One 12-inch disappearing carriage, model 1896, four 12-inch barbette carriages, model 1892, five 10-inch disappearing carriages, model 1894, two 8-inch disappearing carriages, model 1894, twenty 7-inch siege mortar carriages and platforms, twenty 3.6-inch field mortar carriages and platforms and for issue to the Military Academy, 1 model 12-inch seacoast mortar carriage, one-tenth size, 1 model 7-inch siege mortar carriage and platform, one-tenth size, 1 model 3.6-inch field mortar carriage and platform, one-tenth size.

The following carriages have been commenced and partially completed: Four 12-inch disappearing carriages, model 1896, three 8-inch disappearing carriages, model 1894, three 12-inch gun lifts to be altered to 12-inch barbettes.

The change in design of these last three was so long delayed that I could not, as I expected, complete them during the year, but they will be ready for issue in the early fall.

Also partially completed, one 12-inch B. L. barbette carriage, one-tenth size, for the Military Academy at West Point.

The manufacture of carriages occupies probably two-thirds of the facilities and time of the shops, the other third being occupied in the manufacture of cast-iron shot and shell of various calibers; machines for garrison service, mechanical maneuvers, and for mounting and dismounting of guns and carriages; implements for the service of seacoast guns; inspecting templets, gauges, and calibers, etc. Indeed, aside from the guns themselves everything for their mounting and service is provided from this arsenal.

Among these may be enumerated:

Shot and shell from 12-inch B. L. mortar shell to 5-inch rapid-fire shell	1,754
Blocks and shifting planks	3,128
Rollers	345
Handspikes	122
Skids	99
Sling chains	23
Gins	3
Capstans	5
Cradles	3
Rammers and staves, assorted sizes	71
Sponges and staves, assorted sizes	55
Sets of testing tools, caliper and leveling tools, templets, etc	26

Shot tongs, pinch and elevating bars, sponge covers, trunnion chains, trace ropes, chocks, tackle blocks, etc.

ALTERATION AND CONVERSION OF CARRIAGES.

The appropriation for the alteration and conversion of the 15-inch and 10-inch smoothbore carriages has not been renewed, and the appropriations for other carriages being specified, it would seem as if the work upon these old carriages had come to an end. It is my belief

that there are a considerable number of 15-inch guns yet mounted in secondary sites upon the unaltered carriage, capable of only using 50 pounds of powder at a charge, and as this piece is yet a part of our armament and many of them mounted on the strengthened carriage, with hydraulic cylinder, that there should be a small surplus provided for the exigencies of the service. There is not a single 15 inch altered carriage or a carriage for the 8-inch converted rifle in store.

FOUNDRY.

The size of gun carriages has been steadily growing since the commencement of the establishment of this plant five years ago. The designs and material have also changed. The greater part of the 12-inch disappearing carriage, including the larger castings, are now made of cast iron, where formerly, and in the first designs of the smaller carriages, they were made of steel. The steel castings were bought by contract; we will make the iron castings in our foundry. The consequence is, that while under the old conditions the foundry was equal to the demands upon it, under the new conditions it can not produce half enough castings to supply the machine shop. It should be enlarged by its extension through to the end of the building in which it is located. It is advisable to make our own castings as well as forgings, not only for economical reasons, but to maintain standards. It is believed the Government has profited in several ways by the high qualities of the castings produced here. It has proved conclusively that large castings can be made right along absolutely sound, free from sand or blowholes, easy to work, tough, and strong. The iron in all of the larger castings runs uniformly in the neighborhood of 33,000 pounds per square inch.

Each part, cope and bottom molds, of the 12-inch disappearing carriage weighs, when dry, fully twenty-odd tons, and before it is put in the core oven it weighs fully 25 tons. This is too great a strain upon the 20-ton traveling crane in the foundry. We lost one mold and destroyed the flask by the breaking of the hoisting chain of the crane, and are liable to lose more right along. As the loss of a mold and flask means a loss of about $1,000, it would seem advisable to put in a crane of an increased capacity as soon as possible.

The brass foundry was occupied during a portion of the year, in addition to work on carriage castings, in casting breechblocks and breech plates for 8-inch, 10-inch, and 12-inch rifled guns manufactured at Watervliet Arsenal. They were made of console metal, 55 per cent copper, 44½ per cent zinc, and one half of 1 per cent tin. An average tensile strength of 50,000 pounds and upward, with elongations of 30 and 40 per cent, was readily obtained. Much depends upon the quality of zinc used in obtaining good results in this metal, and an addition of 1 per cent aluminum has a good effect. Thorough stirring just previous to and during the pouring of the metal prevents liquation, and blowing with a hand bellows upon the surface of the metal keeps dross and dirt from entering the mold.

These castings were furnished at about 12½ cents per pound.

FORGING DEPARTMENT.

During the year the smith shop has been actively occupied in the manufacture of forgings, principally of steel. The largest piece forged was the gun-lever axle of the 12-inch disappearing carriage. The rough billet, of No. 3 steel, weighed 8,840 pounds, and the axle, when rough-forged, about 8,400 pounds. The cost was about $500 for labor and

material, or about 6 cents per pound. The same forging could not have been bought by contract for less than 9 cents per pound, or about $750.

Our facilities are not quite up to the requirements for handling, heating, and forging such large pieces with speed and economy. With a sufficiently large furnace to heat the piece quickly, large enough crane to handle it readily, and a larger steam hammer to reduce the billet to shape, one of these axle forgings ought to be made for about $425, or about 5 cents per pound. Rough machined it ought to cost no more than 6 cents per pound, and this is of the highest quality of gun steel and a much more intricate shape than any gun forging. When the Government can buy the billets for steel forgings of any size or shape needed, in any quantity, whether for guns or gun carriages, it would be economy for it to erect its own forging departments. In this view it would be advisable to increase the facilities of the smith shop by erecting a larger furnace and putting in a 10-ton steam hammer and a 15-ton crane.

During the year the smith shop has been reconstructed to a great extent. The furnace was rebuilt and made as large as the situation allowed. A larger boiler was put in place of the old boiler, which had become weak in places. This new boiler, like the old one, is located over the furnace, and is heated by the waste heat from the furnace. It is a very trying position for a boiler, as the great heat from the forced draft strikes its near end with much force, but the saving of fuel in a year probably more than equals the cost of a new boiler.

A bolt-heading machine, capable of making bolts up to 2 inches diameter, has been put in, and effects a great saving in the cost of bolts. Our bolts must be very excellent, and of better material and make than can be bought in the market.

A very great saving of power has been made in the reconstruction of the smith shop by locating the blower in the machine-shop cellar, where it can be kept clean and its belts free from the gases and dirt of the smith shop, and by the erection of a 15-horsepower engine to run the shears, bolt machine, and a couple of small trip hammers, supplied also with steam from the boiler over the furnace. This enabled us to do away with the long shaft through the smith shop, run by wire transmission from the machine shop. In this manner a saving of some 40 horsepower per day is estimated, while the appearance of the shop has been improved and the convenience of operations greatly increased.

POWER PLANT.

The boiler plant has been reconstructed and renewed entire during the year. The four boilers of 50-horsepower capacity each were removed and three boilers of about 125 horsepower, at 75 pounds pressure, were put in, but placed perpendicular to the old line of boilers, to admit the entrance of a narrow-gauge track for bringing in coal. The boilers were tested to 200 pounds water pressure per square inch. They are considered to be fully capable of sustaining a steam pressure of 130 to 150 pounds per square inch, should it be deemed advisable to put in a compound engine.

Our machine-shop engine of 150 horsepower is overloaded, and the power requires to be nearly doubled. This will be done very soon, as the money is available for another engine. The delay now is occasioned by efforts to secure the utmost economy of space for the increased engine plant.

Considerable study has been given to the question of the relative economy of a high-speed or low-speed engine, simple or compound, and

to the most economical fuel—whether lump anthracite coal, pea or buckwheat anthracite coal, or soft coal. We have been running for years on lump anthracite coal, delivered in the bin or boiler house, or wherever needed, at an average price of about $5.10 per ton of 2,240 pounds, which is about $4.55 per short ton.

In addition to the machine-shop engine, our boilers supply steam to the carpenter-shop engine of about 75 horsepower and to the testing-department engine of 15 horsepower. There has been a draft upon the boilers (two of them only in operation at one time, the third reserved for extra occasions) ordinarily in summer of steam for 200 horsepower, and when all the tools are running in the carpenter and pattern shop, of 225 horsepower, and this upon a consumption of about 5,500 pounds per day of eight hours.

The boilers are of the ordinary horizontal tubular type.

It is stated that an ordinary performance for a noncondensing engine is 4 pounds of coal per hour per horsepower; hence 200 horsepower $\times$ 8 hours $\times$ 4 pounds = 6,400 pounds would be the daily consumption at this rate. This allowance of coal is probably high. Our consumption is about 3½ pounds of coal per horsepower per hour. It is true that there are boiler plants giving better results, but a thorough study of the problem of cheap power involves more time and skill than in the rush of work imposed upon us we could give it. Indeed, the setting up of temporary boilers, the removal of the old ones, and the erection of new, using the old smokestack, whose capacity is completely exhausted by the present boiler plant, was quite a serious hindrance to the steady pressure for work. We shall have to await more leisurely times before undertaking a solution of the most economical boiler plant question.

ELECTRIC PLANT.

An electric lighting plant was installed during the year. The generating plant consists of one multipolar dynamo, with a capacity of 50 K. W., General Electric Company's make, directly connected to a high-speed engine of about 75 horsepower of the Ideal pattern, operating about 45 arc lights, 275 incandescent lights, and some 20 portable lamps distributed throughout the shops.

Arrangements are being made for operating one of the large cranes in the erecting shop by electricity.

The specifications for the electric plant will be found in the appendix to this report.

The plant was in operation for several months of the year, and gave entire satisfaction.

The engine and dynamo are so located in the room that duplicates can be placed there whenever necessary, there being ample space.

The contract price of the entire plant ready for service was $5,610, the General Electric Company being the contracting parties.

ENLARGEMENT OF PLANT.

The amount and character of the various work orders given this arsenal in the last several years indicate the fixed policy of the Department—that it is not only to be used as a heavy gun carriage factory, but in addition supply all the machines for garrison service and for mechanical maneuvers. Being situated upon a navigable stream, with railways convenient, and centrally located with respect to the larger harbors and big cities of our exposed seaboard, in the midst of numerous manufactories and skilled workmen, it would seem that the work

assigned this arsenal would rather increase than decrease with the accomplishment of our system of coast defense. As time is required to build shops and buy machine tools, the work of enlarging this arsenal to meet the growing demands of the service should be entered upon at once. The size of the plant and its capacity should conform generally to the size and capacity of the gun factory, but the amount expended in recent years in enlarging and improving it is hardly one-tenth that expended on the gun plant. Barely sufficient money has been appropriated to reconstruct the old establishment and build accessory shops. The plant should be duplicated, so that in an emergency the present output could be doubled. We have progressed far enough with our carriage and other work to know just what machines will be required.

TESTING DEPARTMENT.

During the year the testing department has carried on, as heretofore, public tests in the examination of material for acceptance representing the current work at this and other arsenals and places where Government work is in progress.

Investigative tests have been continued; also tests made for private parties who have availed themselves of the use of the testing machine and have defrayed the cost of such testing, as provided by law.

The public tests of material for acceptance include material for field and siege guns, howitzers, and seacoast guns and mortars, the test of steel for small arms barrels and receivers, and for machine guns.

The material used in the 8-inch, 10-inch, and 12-inch disappearing carriages, and anchor bolts for the same, have been tested.

Material from a 12-inch mortar carriage recoil cylinder that burst in service was examined.

There were tests of helical springs for 7-inch mortar carriages, balata slabs for buffers, cast and pig iron from the arsenal foundry, steel plate for the new 72-inch arsenal boilers, chain iron, cast copper, cylinders for pressure gauges, bronze breech plates and loading trays from Watertown Arsenal foundry, material all of which pertained to the Ordnance Department.

Tests of steel bars were made for the Engineer Corps, U. S. A., chain cable for the Light-House Board, a large swivel shackle for the Bureau of Equipment, Navy Department, and shot lines for the Life-Saving Service.

Among the investigative tests are additional experiments on the hydrostatic test of the 8-inch tube section, supplementary to the main series of tests, which has been completed.

The scope of the investigation of this tube section has been so extended as to include all cases of simple strains and nearly all combinations of simultaneous orthogonal strains to which the tube of a gun would ordinarily be exposed.

The exact results, confirmatory as they have been to accepted formulæ, are believed to have a value fully justifying the large labor involved in carrying out this unusual series of determinations.

Heretofore in these tests the strains have been maintained within the elastic limit of the metal. Preparations are now being made to follow with overstraining forces and investigate the effects thereof.

The elastic properties and tensile strength of steel music wire have been determined. The grade of steel employed and the process of manufacture causes this wire to represent the highest strength attained with any of the materials of construction, and they show a decided advance over earlier tests reported in this class of material, one variety running as high as 462,000 pounds per square inch.

Additional samples of "vibration proof" bolts and nuts were submitted by the manufacturers for test as to their ability to withstand unlocking while subjected to vibratory influences. The tests made confirmed earlier experience and failed to substantiate their claim to being vibration proof under the condition of jarring with hammer blows, the method of testing which was adopted.

A number of samples of granite from the State of Georgia, contributed by the Geological Survey, were received and tested. There were brick and terra cotta from the Pacific Slope and from the State of Ohio.

Other tests of building material comprise the test of an important series of cement concrete cubes and columns. The columns were of different heights and laid up of different proportions of cement, sand, and gravel.

The ultimate crushing strength of the material was ascertained, and complete observations made on the compressibility and resilience under successive increments of loads. In this class of material, by varying the proportions of the constituents it is possible to exert a controlling influence on both the ultimate strength and the rigidity, as shown by the modulus of elasticity of the columns.

The prominence which concrete construction is assuming makes the data developed by these tests of much practical value in architectural designs.

The strength of cordage was ascertained in another exhaustive series of tests. The experiments included manila, hemp, sisal, and cotton rope in the various commercial sizes, from a 6-thread manila line to a 10-inch rope.

In addition to the usual determinations of ultimate strength, data relating to the elastic properties were ascertained, the influence of wetting on the length of the rope, when loaded and when free from stress. The effects of wetting are found to be more complex than popularly supposed, and not in all cases accompanied by a contraction in the length of the rope. Under some conditions of loading the immediate effect of wetting is a slight stretch.

The strength of manila and hemp fibers was shown to exceed 100,000 pounds per square inch.

Measurements of the several strands and individual threads of a strand taken from a piece of rope of a given length show, from the variation in length of the elements, wherein a rope must necessarily sustain loads of greatly differing intensity on the different fibers, and illustrate why a fractional part only of the aggregate strength of the fibers is realized in the finished rope.

With the complete tests of the various commercial sizes and the examination of the elementary features of rope construction, the elastic properties and behavior of wet rope, together with the strength of knots, hitches, and splices, which was also ascertained, it is believed the present series furnishes more complete data on this subject than has heretofore been brought together, and will serve as standards for reference where a knowledge of the strength and behavior of ropes is required, aiding in the comparison of present methods of manufacture with such improvements as the future may bring about in this important industry.

A limited number of samples of steel-wire rope were tested, representing types differing in size and number of wires, including those with and without jute cores. These samples represent rope intended for different purposes to meet requirements of strength or flexibility, as the case may be.

There was a series of tests on full-sized wooden posts. New posts of long and short-leaf pine, and spruce and old long-leaf pine posts from a building where the latter had been in use for a period of about fifteen years.

In the tests of new sticks posts were taken from the butts, from the middle, and from the tops of the trees and the difference in strength due to position thus ascertained, approximately, it may be stated as 100, 90, and 80 for butts, middle, and tops. The posts represented different degrees of dryness of the wood, the percentage of moisture being ascertained after the test by cutting out a short section of the post in the vicinity of the place of fracture.

The strength of the old posts, which were in a state of extreme dryness, largely exceeded the strength of the comparatively green sticks, and also was greater than the strength of timber which had been in the yard for a period of two years.

There were a number of charred posts from the upper stories of the building, in which there had been a conflagration a number of years ago. Necessarily much practical value attaches to the tests of posts which have been exposed to such vicissitudes in use.

The occasion of installing a battery of new boilers into the arsenal plant gave the opportunity of making some observations on the behavior of riveted joints in actual construction supplementary to the tests of joints in the testing machine. The boilers further afforded the opportunity of obtaining data upon the general behavior of different details in steam-boiler construction, all of which information assists in the application of results obtained upon material in the testing machine to the varied conditions of constructive experience.

The boilers were examined over the joints, and on corresponding gauged lengths on the solid sheet, the strains in the vicinity of the manhole, the contraction in length of the shell while under hydrostatic pressure, the elongation of the tubes under the same conditions, and the examination of the bending strains at the roots of the flanged heads incident to the contraction of the shell and the expansion of the tubes. All of these features are included in these observations.

The meager information pertaining to the actual stresses in steam boilers gives special importance to this class of tests.

In the chemical laboratory analyses have been made of all material of unusual strength or other unusual physical properties, and a sufficient number of determinations made to indicate the composition of the steel ordinarily used in ordnance construction.

Photographs have been taken of material under test, and the appearance of specimens after rupture shown.

In order to show the range in the amount of hygroscopic water absorbed by or lost by ropes exposed to atmospheric conditions, weighings have been made of samples from time to time extending over a period of several months.

Other work accomplished in the testing department in addition to the direct work of testing, has been the designing of an apparatus for the endurance tests of shafts, a 6-specimen machine, in which the stresses may be made to alternate from tensile to compressive stresses of equal magnitude, or where either tensile or compressive stresses, one or the other, may be the greater, the opposite stress being diminished to zero or even alternating between a maximum and minimum value of the same kind of stress.

These combinations are made possible by applying simultaneous bending and endwise stresses to the rotating shafts.

With the introduction of various grades of steel possessing high physical properties in the testing machine, the importance of ascertaining the endurance of the metal under conditions analogous to those of service becomes the more apparent. The endurance of metal under repeated stresses might reasonably be supposed to indicate the most desirable manner of attaining these high physical properties, whether by chemical composition, mechanical means, or by heat treatment.

An impact machine has been designed. This is of the vertical type and will admit of attaining velocities of about 20 feet per second. The parts of the apparatus have been designed very massive for the purpose of obtaining great rigidity under the shock of testing.

So vague is the information at present available on the subject of impact that elementary tests are necessary to establish a working basis of operations.

One of the ends constantly kept in view in the design of the vertical impact machine was to provide suitable machinery for acquiring fundamental data; hence in the present machine it is expected to ascertain and define the resistance in detail encountered in the deformation of material by sudden applied loads.

It is proposed to introduce microscopic metallography in the investigation of constructive materials and the appliances necessary to this end have been obtained. The intimate relations existing among tests by impact, the effect of heat treatment, tempering and annealing of steel, the effect of repeated stresses and internal strains, are such that much aid is expected from the microscopic inquiry.

It is further expected that the facilities afforded by the standard comparator will be of importance in certain investigative directions, and microscopic research be accessory to investigative work of importance heretofore impracticable to undertake.

The apparatus already provided for and that which has been designed should be considered collectively as well as in detail, as each part will reinforce the others and aid in filling breaks in the continuity of present information.

The room set apart on the second floor at north end of the testing laboratory for a museum of interesting specimens has been provided with cases for the reception of material and already contain specimens which have been reserved for exhibit. In time past a large amount of valuable instructive material has been lost for want of a place where it might be carefully preserved. There is, however, an almost constant tendency to accumulate interesting material in the testing department, and the present facilities for the collection of specimens will be immediately improved.

Including the report of 1896, the proof sheets of which have been read, there has now emanated from the testing department sixteen annual reports, "Tests of metals," etc., and the seventeenth volume is in course of preparation.

These reports cover a wide range of material, and from the nature of the case information on a given subject is often disseminated among several reports covering more or less remote periods of time.

It is believed that a compilation of the data embodied in these several reports might with great advantage be brought together in a concise form and published in a special volume, classifying and arranging the data according to subjects.

Such a volume should present the general results thus far developed, following substantially the same method as adopted in the several annual reports—that is, presenting the facts of the tests, omitting the expression of opinion and comments upon the results.

NORTH BEACON STREET.

The matter of the condition and control of North Beacon street is calling for some definite settlement. April 5, 1824, the President of the United States gave a revocable grant to the Waterford Turnpike Corporation for the passage of a turnpike road through the lands of the United States at this arsenal. This road is now a part of North Beacon street, one of the main avenues of travel between Boston and Watertown and the towns beyond. The turnpike corporation long ago passed out of existence and the road reverted to the United States. It is, however, used by the public, and is nominally under control of the town of Watertown. But it is in bad order for travel, very little repair is ever made to it, and no police supervision is exercised over it. It is unsafe for travel at night by reason of want of police control. An act of Congress should grant the road to the town of Watertown.

WHARF ON CHARLES RIVER.

The wharf upon the Charles River, for which there was an appropriation, has been completed in a most workmanlike and substantial manner. It will last as long probably as there will be any occasion for an arsenal at this point.

A railroad connecting the wharf with the shops and the Fitchburg Railroad is being built. We will very soon be enabled to ship our carriages by rail or water, as seems most desirable or economical.

ADMINISTRATION BUILDING.

The absolute necessity of a larger administration building for this arsenal makes itself more apparent from day to day. Our work has steadily increased for the last five or more years, and office work has increased in a greater ratio. Without sufficient clerks and thorough office system no manufacturing establishment can be carried on satisfactorily or successfully.

We employ now an average of 275 men. To keep the time of these men accurately, so that we may know the cost at any time of each and every item of manufacture, or part thereof, requires a more detailed system of time cards than has obtained here in the past. Our pay rolls have to be made out very hurriedly in order to pay the men at an early day of the succeeding month. The records of the office have to be kept up to date. Contracts for materials under the law are being made almost every day. Receipts and issues are of daily occurrence. We have all the office details of a private manufacturing establishment, and in addition that required on Government account. I find a private establishment of this magnitude would employ at least a dozen clerks and typewriters. We have four clerks and one typewriter, not half enough office force to inaugurate or maintain a thorough and efficient system of administration. Yet the office building has not room for another clerk.

Records and office books of all kinds should have safe storage and be readily accessible. Officers who have technical duties to perform require at times a room free from interruption. There should be rooms available for the meeting of boards, courts-martial, etc. If a meeting of the civil service board is called, it should not be necessary to drive officers or clerks from their desks. If a court-martial convenes to try a soldier, it ought not to be in the office of the ordnance storekeeper with

his clerks endeavoring to perform their functions. . The draftsmen's room should be easily gotten at by foremen in search of prints or like information, and not where, practically, they have to pass through the commanding officer's office to get them. It is a wonder that we are able to accurately keep our accounts, make intelligent estimates, or answer promptly and correctly the thousand and one questions that arise right along in the administration of an army manufacturing establishment charged with new types of gun carriages, and all the implements and equipment of seacoast fortifications, a steadily growing and changing affair. Only a very lively interest in one's duties, far beyond the perfunctory performance of duties and extending beyond hours of labor, enables the officers and clerks at this arsenal to do the work devolved upon them. I can not urge too strongly the necessity for a better administration building at the earliest opportunity.

I desire to express my acknowledgment of valuable assistance rendered me by the following officers, assistants at this arsenal:

To Capt. Frank Baker, Ordnance Department, for work in connection with the building of the wharf on the Charles River;

To Capt. F. E. Hobbs, Ordnance Department, for work in connection with the clinometer for graduating elevating arcs of gun carriages;

And to Lieut. C. B. Wheeler, Ordnance Department, for work in the preparation of the specifications for the electric plant.

(10222—Enc. 135)

APPENDIX 18.

A STRIDING CLINOMETER FOR GRADUATING THE ELEVATION CIRCLES OF GUN CARRIAGES.

(1 plate.)

As its name indicates, this instrument was devised to provide a means of accurately graduating the elevation circles of gun carriages. The various forms which an instrument to accomplish this purpose might take and the various ways in which it might be applied to the mounted gun were fully discussed before any work was undertaken, and there seemed to be no objection to the decision finally arrived at that the clinometer should be of striding form and be applied in the axis of the gun at the muzzle. The necessity for any modification of the instrument or means of its application has not developed in the limited amount of use to which it has been put.

The instrument consists of a tubular base B (see accompanying drawing), to which are attached the supporting legs L, the arc C, and the movable vernier arm A. The metal parts are of brass, except the graduated surfaces of the arc body and the vernier, which are silver.

The base is stiffened by a vertical rib I, which is made in one piece with the arc, and the ends are closed by caps screwed in. The legs are open at an angle of 90° and the bearing surfaces are slightly rounded. The arc is securely fastened into the base and has on one side the silver surface bearing the graduations. A division on the arc is ten minutes, and, by means of the vernier, readings are made to one minute.

The vernier arm is attached to the base by means of the lug E of the stiffening rib and pivots on the screw S, the axis of which is the arc center; the arm carries the principal level G, the cross level D, the vernier V, the adjustable reading glass R, with its attaching arm and glass shade, and the clamp screw K.

The levels have means provided for vertical and lateral adjustment; the bubbles are sensitive, and the glass tubes are accurately ground and graduated. One division of the graduations on the principal level, 0.15 of an inch long, corresponds to twenty seconds of arc and one division on the cross level, 0.1 of an inch long, corresponds to one minute of arc.

A holder H is provided for holding the clinometer in place when it is being used. This holder is fastened to the supporting cylinder by the clamp screw M, and permits the clinometer to be adjusted laterally by means of the opposing tangent screws T.

The clinometer is applied to the gun by being mounted on an axial cylindrical projection from a cylinder closely fitting the bore of the gun and placed in the muzzle. On the drawing the 8-inch cylinder Y is shown in an 8-inch gun N. The diameter of the cylinder is 7.997 inches, the length 24 inches. The axial cylindrical projection J (which is actually the end of a bar passing through the cylinder) is very accurately finished at Z, the seats for the clinometer legs, while a shoulder

at O gives a constant position for the instrument and prevents slipping when using it at the higher elevations. Cylinders are also provided for guns of 10 inches and 12 inches caliber. The axial projection is finished to exactly the same dimensions on all the cylinders.

The instrument weighs about 4 pounds, and a neat packing case, with carrying strap, is provided for its storage and transportation.

The method of using the instrument is simple, but requires that very great care should be exercised; not that it is particularly delicate, but on account of the sensitiveness of the level bubble, which should be free from irregular temperature effects.

The bore of the gun is first thoroughly cleaned at the muzzle for a length at least as great as that of the cylinder. The cylinder is then inserted its entire length until the stop on its face bears against the muzzle. As the fit of the cylinder is very close, care should be taken to have it thoroughly clean and to avoid burring up the surface as it is being inserted into the muzzle. Either dirt or a burr will cause slight inaccuracies in the graduations to be made.

See that the seats for the clinometer legs are perfectly clean. Fasten on the holder. Set the arm at zero.

The instrument is habitually handled by the base. Note especially that in putting the clinometer in position or in removing it that it should be placed or lifted with both hands, grasping it at the ends of the base, and also in setting the vernier arm the clinometer should be held with the left hand grasping the base while the right hand operates the clamp screw.

Place the instrument in position and adjust laterally by the tangent screws of the holder until the cross-level bubble is in the center of the tube, or very nearly so. Note especially that these tangent screws should never have a hard bearing against the base; permit a play of several thousandths of an inch, or even so much as a hundredth of an inch, and in replacing the instrument in position bring it to touch against one or the other of the screws. The tube of the principal level is so accurately ground that slight inclinations either way, as shown by the cross level, will have no effect on the position of the bubble in the principal level.

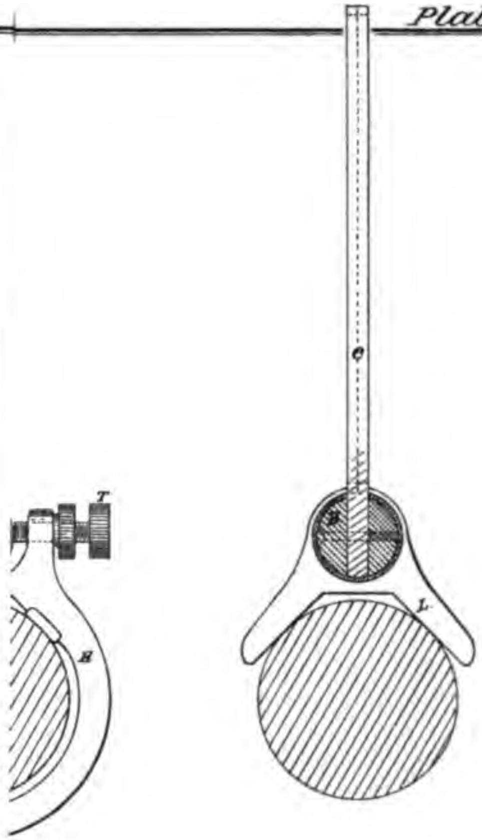
Elevate or depress the gun until the bubble of the principal level is in the center of the tube; reverse the instrument to test the adjustment; if out of adjustment, correct by the usual method employed for spirit levels, one-half the error by the opposing nuts and one-half by the elevation of the gun. Repeat until the adjustment is perfect. It may be noted that with so sensitive a level as is on this instrument if the bubble return on reversing to within one-half a division of its original position the adjustment may be considered sufficiently accurate for the work to be done.

The graduation of the elevation circle or arc may now be made. In general it will be sufficient to mark every ten minutes. These ten-minute spaces can be divided in the shop when the graduations are cut. The graduation should be checked by elevating and depressing the gun to several specified graduations. It has been found in practice that an approximation, in setting to a specified graduation, within the limits plus and minus, about eight seconds is as close as can be made—i. e., in a number of attempts the extreme variation noted will be about as stated.

The instrument is reversed for graduations in depression.

(10222—Enc. 136)

Plate I.



ing Clinometer.—

APPENDIX 19.

SPECIFICATIONS FOR AN ELECTRIC LIGHTING PLANT AT WATERTOWN ARSENAL, WATERTOWN, MASS.

GENERAL.

It is the purpose of these specifications to cover a complete electric lighting plant delivered and installed at Watertown Arsenal, Watertown, Mass. It shall be understood and agreed that these specifications shall be fulfilled in their true intent and spirit, and that any apparatus or appliance essential to the proper and convenient operation of the system shall be supplied without extra charge, even though not specifically called for, in order that the plant shall be complete and first-class in every particular when turned over for inspection and acceptance.

The contractor shall begin work as soon as possible, and the work shall be prosecuted with rapidity consistent with thoroughness and good workmanship. The contractor shall personally, or through an authorized representative, constantly supervise the work from the beginning to its completion and acceptance.

He shall furnish the necessary transportation, labor, apparatus, and materials to complete the work, and whatever else may be necessary for its protection until accepted.

He shall at all times, until its completion and final acceptance, protect the work, apparatus, and materials necessary for performing the work as specified from accident or other damage, making good any harm thus done at his own expense. He shall also make good any injury to the buildings while the work is being prosecuted.

Any doubt as to the meaning of these specifications or any obscurity as to the wording of them will be explained, and all directions and explanations necessary or proper to make more definite any of the provisions of these specifications and give them due effect will be given by the commanding officer, and such directions and explanations shall be binding on the contractor the same as if they had been contained herein.

Whenever the contractor is not present, orders will be received and obeyed by the authorized representative or overseer who may have charge of the men employed on the work.

WORK, LABOR, AND MATERIALS.

All work contemplated by these specifications shall be executed in a workmanlike and substantial manner to the satisfaction of the commanding officer, and the workmen shall be only those especially fitted for the work given them to do. All materials shall be of the highest grade and the best the market affords. Whenever requested, samples shall be submitted for examination or test.

Additional work will be allowed only on the written order of the commanding officer, and specified work shall be omitted or changed

only by written agreement between the contracting parties. The addition or rebate for such added, omitted, or changed work shall be mutually agreed upon, the amount to be stipulated in the order of agreement.

REPLACEMENT OF DEFECTIVE MATERIAL.

No material furnished, nor work done, is to be considered as accepted which may be deficient or defective in any of the requirements of these specifications, in consequence of any negligence of an inspector or other authorized person to point out such defect or deficiency during the execution of the work, and the contractor will be required to replace any inferior material or correct any imperfect work whenever discovered. He must also remedy any defects from the above causes for a period of ninety days after the acceptance of the work.

SPECIAL DEVICES.

Every bidder is expected to include in his proposal not only everything called for in these specifications, but also any special methods or devices peculiar to his system which will add to the safety, completeness, or efficiency of the plant.

SAFEGUARDS AND DÉBRIS.

Contractors must provide all necessary safeguards from accidents to persons or property; must keep all passages, entrances, etc., free from débris and incumbrances, and on completion of the work must remove from the arsenal all surplus material of every kind and description.

PLANS.

The contractor shall make the necessary plans for the lay out of dynamo room, giving detailed dimensions and the necessary data for foundations. These plans will be submitted for approval before the work is commenced. The foundations will be built by the Ordnance Department.

GENERATING PLANT.

The generating plant shall consist of one multipolar dynamo directly connected to a high-speed engine of suitable capacity. When dynamo and engine have not the same base, the separate bases shall be so connected together as to insure rigidity.

The dynamo will have a capacity of 50 KW., or 434 amperes at 115 volts at about 300 revolutions. It will be compound wound and over-compounded for a loss of 5 per cent in the lines. The armature shall be of the ironclad type, so arranged as to be thoroughly ventilated by means of air ducts not less than one-half inch in width, and shall be made of laminations dovetailed into projections of the armature spider, by which construction no bolts pass through the core, the laminations being thoroughly insulated from each other by means of a coating of japan or other insulating material. The machine shall be equipped with carbon brush holder and brushes, and the commutator shall be of such dimensions that the current density shall not exceed 30 amperes per square inch under the full load rating of the machine.

The machine shall be guaranteed to run for ten hours on full load without heating in either armature or fields more than 35° C. above the surrounding air.

The dynamo shall be guaranteed to carry 25 per cent overload without appreciable sparking and without excessive or dangerous heating. The brushes shall be capable of remaining fixed for considerable changes in load.

The efficiency of the machine at full load shall not be less than 91 per cent, at half load 89 per cent, and at quarter load 85 per cent.

The dynamo shall be equipped with a suitable rheostat of the carpenter enamel type, adapted to be mounted in the back of the switchboard, with the handle only in front.

The generator shall be noiseless and free from vibration when running, and have self-lubricated bearings. The high-speed engine furnished shall have a capacity of at least 75 horsepower. It shall be double-acting and noiseless, and free from vibration when running. The bearings shall be self-oiling. The engine must have an automatic governor and be fitted with hand and automatic relief valves. The engine furnished must be equal to the Ideal, Payne, or McEurn.

When the engine is acting with the normal steam pressure the governor must act so that the maximum variation in speed shall not exceed 2 per cent when the load is varied either slowly or suddenly from full load to one-fifth full load and back. From full load to no load and back the allowed maximum variation will not exceed 4 per cent. The engine must steady itself at once and no hunting will be allowed.

When the steam pressure is varied from 20 pounds below the normal to 20 pounds above the normal the variation in speed will not be greater than 2 per cent of the speed at normal pressure.

After the plant is installed the contractor will make such tests as the commanding officer shall require, including the following:

The insulation resistance of the dynamo circuits before and after a continuous run of ten hours, and the copper resistance of shunt series and armature coils, and the heating of the various parts of the generator. After the heat run the generator shall be run to obtain its external characteristic curve and indicator cards shall be taken at the various loads.

The engine shall be tested for governing and cards shall be taken at the different loads to determine the efficiencies.

Bidders will furnish drawings of the generators and engines which they propose to furnish.

SWITCH BOARD.

The contractor shall furnish and install a suitable switch board in a convenient location near the generators. The switch board shall be constructed of enamel slate 1½ inches thick, set in an angle-iron frame with polished brass supports. The board will be so constructed that extra panels may be added, if necessary. The switch board shall be adapted for the generator above described and for eight separate sets of feeders.

All connections to instruments and switches shall be made on the back of the board with solid rolled copper.

All connections shall be based on a standard of 1,000 circular mils per ampere, assuming that the copper is 96 per cent pure.

All joints and connections shall not heat appreciably above the temperature of the surrounding air at full load. On the face of the board will be mounted the following instruments and switches: One Weston round-pattern ammeter, 550 amperes; one pilot lamp; one Weston round-pattern volt meter, 125 volts; one ground detector with necessary switch; one Carpenter enamel rheostat (handle only in front); eight double-pole feeder switches; one triple-pole single-throw dynamo switch.

All switches to have the necessary fuse studs and fuses.

All switches to have an ample margin above the present calculated capacity and to be clearly marked to indicate their capacity and to have the name of the manufacturer.

All switches shall be of the type that has the approval of the underwriters for similar class of work.

In addition to the above switches to be mounted on the switch board, the following will be supplied and installed:

Carpenter shop.—One double-pole switch, 30 amperes.

Testing room.—One double-pole switch, 15 amperes.

Paint shop.—One double-pole switch, 5 amperes.

Office building.—A 5 or 10 ampere switch in each room to be lighted, for controlling the lights in that room.

Museum.—One double-pole switch, 10 amperes.

Foundry.—One double-pole switch, 40 amperes.

CABLE CONNECTIONS.

The dynamo shall be connected with the switch board by rubber-covered cables of 250,000 centimeters capacity; these cables to be taken from the connecting lugs of the dynamo and run on porcelain insulators in a neat and substantial manner. The field wires shall be No. 10 B. & S. and shall be run to the switch board in brass-armored conduit supported by porcelain cleats.

WIRING.

The contractor shall wire to the outlets complete, furnishing everything necessary for a complete and first-class installation. All wiring shall be done with triple-braid weather-proof wire of approved pattern and shall accord in every way with the requirements of the New England Insurance Exchange.

All wires, with the exception of those in the office, testing room, and museum, shall be run on porcelain insulators and cleats.

Insulators and cleats shall be of approved design and shall be run in a neat manner and secured to the walls and ceilings with screws.

All wires shall be run taut and parallel to side walls.

Wherever wires pass through walls and partitions they shall be bushed with porcelain tubes. At the entrances and exits of buildings the strain from the wires shall be taken by bracket blocks with double petticoat insulators. These blocks shall be supported by iron brackets held in place by expansion bolts.

Should the space between the buildings where the feeders or mains pass exceed 100 feet, a suitable number of cedar poles shall be installed to relieve the strain. Such poles shall be securely set in the ground to a depth of 6 feet and supplied with cross arms, insulators, pins, and braces, complete. All poles shall be painted two coats of white lead, or such color as the commanding officer may direct. The poles shall be 30 feet long and not less than 6 inches across the top. In the testing room and office all wires shall be incased in neat wooden moldings. All moldings shall be painted on the inside with two coats of insulating paint. After the wires are installed the exterior of the moldings shall be painted to match the surrounding woodwork. The wires in moldings shall be rubber covered, with outside protection of braid.

There shall be eight main circuits or feeders which shall be controlled at the switch board, as follows:

No. 1. Starting from the switch board, one set of two wires to the center of the foundry and foundry extension building.

No. 2. Starting from the switch board, one set of two wires to the center of the erecting shop.

No. 3. Starting from the switch board, one set of two wires to the center of the south wing.

No. 4. Starting from the switch board, one set of two wires to the center of the north wing.

No. 5. Starting from the switch board, one set of two wires to the center of the smith shop.

No. 6. Starting from the switch board, one set of two wires to the center of the carpenter shop and from there to the paint shop, testing room, museum, and laboratory.

No. 7. Starting from the switch board, one set of two wires to the office building.

No. 8. Starting from the switch board, one set of two wires to the stables.

From the end of the feeders mains and branches shall be distributed to feed the arc and incandescent lights in accordance with the distribution below described, these mains and branches being of such capacity that there shall be a loss not to exceed 2 per cent between the end of the feeder and the lamps at full load.

The loss or drop of potential shall not exceed 5 per cent from the switch board to the farthest lamp when each and every lamp is in use, and the drop between the switch board and the ends of the feeders shall not exceed 3 per cent under the same conditions.

The wires shall be calculated allowing a possible increase of 25 per cent of lamps in each building, except those to the erecting shop, which may have 50 additional lights, and the size of the wire shall be approved by the commanding officer before being installed. No size of wire smaller than No. 12 B. & S. will be used.

DISTRIBUTION OF LIGHTS.

The distribution of lamps in the different buildings will be approximately as follows:

	Arc.	Incandescent.
North wing, first floor	2	60
North wing, second floor	0	58
Engine and dynamo room	0	12
Boiler room	1	2
South wing	12	20
Smith shop	4	2
Erecting shop	10	10
Foundry	6	6
Foundry extension	4	10
Paint shop	0	4
Carpenter shop	2	20
Engine room and office	0	3
Testing room	0	7
Pump room	0	4
Museum	0	16
Laboratory	0	4
Office building	0	24
Stable	0	8
Total	41	270

In addition to these, 15 portable lamps distributed through machine and erecting shop.

The distribution of the incandescent lights is calculated to give one incandescent light to each machine and two to the larger machines.

All of these lights should be capable of a lateral displacement of at least 5 feet, and will have sufficient length of cord for this purpose.

The distribution of all of the above lamps in the different buildings shall be determined by the purchaser at the time of installation, and it shall be understood that the purchaser may make, without extra charge, any reasonable amount of changes in same, provided he finds that the best results are not being obtained.

SAFETY AND CONTROLLING DEVICES.

All cut-outs and switches shall be double poled and mounted on bases of porcelain or other fireproof insulating material.

Cut-outs shall be of the Edison plug pattern up to and including 15 amperes. All larger cut-outs shall be of the Edison link pattern.

All cut-outs shall be equipped with a full set of the proper fuses and plugs. A complete set in duplicate will also be furnished.

Cut-outs will be grouped and placed, where possible, in such locations as to permit of easy access. All cut-outs shall be incased in neat wooden cabinets lined with sheet asbestus board one-fourth of an inch thick. Locks of all cabinets to be the same, and three keys are to be furnished.

Lightning arresters will be installed where necessary.

FIXTURES.

All outlets shall be equipped with fixtures complete. The contractor shall furnish and install flexible cord pendants at all incandescent outlets except where otherwise directed. Pendants shall be equipped with a fused porcelain rosette, suitable length of cord, cord adjuster, key socket, and shade holder. There shall also be supplied with each incandescent light either a 10-inch tin enameled shade or wire protector, as may be signified by the purchaser or where not otherwise specified.

The testing room shall be supplied with polished brass brackets, key sockets, shade holders, and fluted porcelain shades, except over machine and desks, where a pendant will be used with porcelain shades, green on top and white beneath, about 10 inches in diameter.

The museum over the pump room shall be supplied with four 4-light clusters complete, with keyless sockets, shade holders, and flat porcelain shades, these four clusters to be controlled by a 10-amoere double-pole switch located at the head of the stairs.

In the office the lamps shall correspond with those specified for the testing room, pendants being used over desks and where brackets can not be used.

The lamps in the stables shall all have heavy wire guards with key sockets, etc., and shall be attached to the wall or be suspended by a cord, as shall be deemed most convenient at the time of installation. In addition to the other wiring, the contractor shall wire to and install 24 outlet boxes throughout the shops where directed. These outlets shall be substantially constructed and installed in a safe manner. He shall also furnish 15 portable hand lamps, complete, with heavy guard, handle, key socket, attaching plug, and 25 feet of suitable cable each.

Throughout the shops where required, on account of the overhead cranes, the arc lamps shall be suspended from wrought-iron brackets attached to the crane posts, and capable of swinging so that the lamp will not be struck by anything suspended by the cranes.

LAMPS.

The contractor shall furnish and install 41 arc lamps and 270 16-candlepower incandescent lamps, and 15 portable 16-candlepower incandescent lamps, in accordance with the distribution above given.

The arc lamps shall be of the long-burning 80-volt type, adapted for 4.5 or 5 amperes, and shall be capable of burning one hundred and fifty hours without retrimming. The lamps shall be equipped with an opal inner globe and a clear outer globe, and to be entirely inclosed so as to be practically dust and water proof. Each lamp, when possible, shall be suspended from a porcelain hanger board, and shall be equipped with its own switch.

The incandescent lamps shall be equipped with Edison bases. They shall be adapted for 110 volts and shall have an efficiency of 3½ watts per candlepower and a fair average life of not less than six hundred hours. In addition to those installed. 30 extra incandescent lamps will be furnished.

ACCEPTANCE.

The contractor shall perform all work as before specified, leaving the same in perfect working order. Upon completion he shall furnish a competent engineer to operate the plant for a period of three days, not exceeding six hours each day, giving necessary instructions to the purchaser's engineer.

The contractor will also, at his own expense, have an inspection made of the entire plant by an inspector of the Insurance Exchange, and his approval obtained before the plant is accepted by the commanding officer.

(10222—Enc. 138)

APPENDIX 20.

INSTRUCTIONS FOR THE INSPECTION OF TELESCOPIC SIGHTS.

1. Examine the telescope by measuring its aperture in inches, its focal distance in inches, and its magnifying power. The best method of determining the magnifying power is by the use of a double-image dynameter, but it is not necessary to employ such an elaborate apparatus in the present case. It will suffice to take the clear aperture of the objective between the points of a pair of dividers and prick it down on a piece of paper. Then, with the same pair of dividers and a magnifying glass, take the diameter of the pencil of light emerging from the eyepiece, and find how many times that is contained in the clear aperture of the objective by using the last opening of the dividers to step the distance between the dots laid down when the objective was measured. The result will be the magnifying power. Finally, examine the definition of the telescope and note whether or not it is satisfactory.

An accurate determination of the focal distance of the telescope is not necessary. The telescope being focused on a distant object, it will suffice to measure the distance from the front of its objective to the pointers, and then deduct two-thirds of the thickness of the object glass.

For determining the field of view the following method is suggested:

When the telescopes of the sight and transit instrument are collimated on each other, the diameter of the field of view can be determined by pointing the transit first on one end of the diaphragm and then on the other, reading the angles, and taking the difference.

2. With a good Brown & Sharpe micrometer caliper, measure the diameters of the steel trunnions, first the forward one and then the rear one. With care there is no difficulty in making this measurement to one five-thousandth part of an inch (0.0002-inch), and if the two trunnions differ more than that the instrument should be returned to the maker for correction.

(N. B.—This test can also be made by means of the striding level.)

3. When the vernier on the arc reads zero, the axis of the sight trunnions, the axis of the telescope level, and the line of collimation of the telescope should all be rigorously parallel to each other. To examine these adjustments it is necessary to have a stand on which to place the trunnions, a striding level[1] to level them, and an engineer's Y-level. To make the examination, place the trunnions on the stand, level them with the striding level, make the cross level read zero, and then by means of the altitude screw of the gun sight make the level on the telescope read zero. This will bring the horizontal plane passing through the axis of the level parallel to the horizontal plane passing through the axis of the trunnions. Then see if the vernier reads zero on the arc. If it does not, either make it do so by means of the proper adjusting screws or note the error.

The vernier is adjusted by means of two set screws, one at either end of the vernier, so arranged that by unscrewing one of the screws and screwing up the other the vernier can be adjusted in the required direction.

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[1] The tube of this level should be graduated to twelfths of an inch and numbered continuously from one end to the other. The bubble should run 1 inch for a change of inclination of 5′ of arc.

Next focus the telescope of the gun sight on a distant object, set up the engineer's Y-level, focus it on a distant object, adjust it carefully to indicate a level line, and make sure that there is no parallax in the eyepiece of either telescope. That being done and the telescope of the level being collimated on the telescope of the gun sight with the object glasses 2 or 3 inches apart, look into the telescope of the level and see if its horizontal wire coincides with the horizontal pointer in the gun sight. If there is any error, note its amount. It can probably be corrected only by the maker, because there is no convenient means of adjusting the pointer in the gun sight. This test shows whether or not the line of sight of the telescope is parallel to the axis of the trunnions in the horizontal plane. It yet remains to be seen whether it is parallel in the vertical plane. For that purpose revolve the sight on its trunnions through an angle of 90°, so as to bring the cross level vertical, and then, having again brought the engineer's level into position, look through it into the telescope of the gun sight and notice whether or not the wires of the level cut the extreme tip of the horizontal pointer when the drift scale reads zero. If they do, all is well; if not, by means of the micrometer at the eye end of the telescope move the horizontal pointer until its extreme tip touches exactly the horizontal wire of the engineer's level. Then unscrew the cap which carries the eyepiece and closes the eye end of the telescope. When that is done the horizontal scale will be exposed, and it will be seen that it is held in place by two small screws. Loosen these screws, shift the scale so as to make its zero coincide accurately with the pointer, tighten the screws so as to clamp the scale firmly, and replace the cap which carries the eyepiece. If these operations are properly performed the horizontal scale will be brought into perfect adjustment; but it should be again tested with the engineer's level to make sure that such is the case.

4. Turn the gun sight down on its trunnions so as to bring it into its normal position, suspend a plumb line before the telescope at as great a distance as is convenient, and rotate the whole gun sight on its trunnions until when the telescope is moved in altitude the extreme tip of the horizontal pointer follows the plumb line. When it does this accurately the cross level should read zero. If it does not, adjust it by means of its screws.

This is done as follows:

Unscrew, by half a turn at a time, each of the two screws of the level just sufficiently to admit of a piece of paper being inserted underneath it.

The paper must be rectangular, having a piece cut out of it in order that it may envelop the screw on three sides. One thickness of foolscap paper raises the level about 1′.

If the pointer was to the right, raise the level on the left side; if to the left, on the right side, by means of the piece of paper put underneath.

Finally, screw the screws home equally and with moderate force. Reapply the test, and if found correct, make a scratch across the heads of the screws on to the metal of the sight. If not correct, the operation must be repeated.

This will make the axis of the level parallel to the horizontal axis of the telescope if the gun sight is accurately constructed. To ascertain whether or not such is the case, repeat the test with the trunnions of the sight at the greatest angle of elevation which will admit of the telescope remaining horizontal. If any sensible error exists, the sight must be returned to the maker for correction. There are no adjusting screws for that purpose.

5. It is important to determine the degree of sensitiveness both of the telescope level and of the cross level. To determine the sensitiveness of the telescope level, bring the bubble to one end of its run by

means of the altitude screw on the telescope and note the reading on the arc of elevation. Then by means of the elevating screw bring the bubble to the other end of its run, and again read the arc of elevation. The difference of these two readings is the amount of arc corresponding to the distance traversed by the bubble in passing from one end of its run to the other. This should be at the rate of not less than 1 inch for ten minutes of elevation. There seems to be no convenient way of testing the sensitiveness of the horizontal level, except by taking it off, fastening it on the telescope, and then testing it in the same way as the telescope level.

6. To determine the value of the horizontal scale of the gun sight, set up a theodolite in such a position that its telescope collimates into the telescope of the gun sight, and measure on the limb of the theodolite any convenient number of the divisions of the horizontal scale of the gun sight, taking the same precaution in focusing before collimating as was done in (3). Dividing the arc thus measured by the number of divisions will give the value of each single division.

7. To test the vertical arc, the most convenient plan will be to fasten the instrument on a stand with the vertical arc lying horizontally and point the telescope on some distant object in such a direction that the vernier is near one extremity of the arc. Read the arc, and then point on another distant object so situated as to bring the vernier nearly to the other extremity of the arc, and read the arc again. The difference of these two readings will be the angular distance between the objects. Then remove the gun sight, set an ordinary theodolite in its place, and measure the angle between the same objects with it. If all is right, the arc measured by the theodolite should be the same as that indicated by the gun sight. In making this test care must be taken to place the center of the theodolite as nearly as possible in the position which was occupied by the axis of the telescope of the gun sight. The vertical limb of the transit may be used for the same purpose when there are facilities for doing so.

(N. B.—If it is thought best, collimating telescopes can be used instead of distant objects.)

8. It is worth while to note that the zero of the micrometer divisions on the screw for changing the elevation of the telescope can be adjusted to make it agree with the zero of the arc. For that purpose, loosen the two small screws on top of the brass head, then turn the ring carrying the divisions into the proper position, and again tighten the two small screws.

9. To test whether or not the pointers move horizontally when they are deflected from the center—or, in other words, whether or not they move parallel to the rotation axis of the telescope—that can be done either with the engineer's transit or with the engineer's Y-level. The telescope of the gun sight being adjusted so that its rotation axis and its line of collimation are both horizontal, and the telescope of the engineer's instrument being horizontal and collimated upon the telescope of the gun sight, when the horizontal pointer should coincide with the horizontal wire of the engineer's instrument, and if the pointers move horizontally the coincidence should remain undisturbed when they are deflected to either side of the field of view by means of their micrometer screw. If the pointers do not move horizontally, they will rise above the horizontal wire of the engineer's instrument when deflected to one side of the field and fall below it when deflected to the other side.

10. Besides the preceding, each sight will be carefully examined for the following defects: Lack of strength and rigidity in the framework

and telescope tube; a loose fitting of the screw thread of the housing of the objective in the tube; failure of the sight to retain its elevation and deflection readings upon a slight jar being given it; parallax of the pointers with reference to the image; backlash between the worm spindle and rack; lack of agreement between the readings of the vernier and the corresponding ones on the micrometer screw; missing, defective, or broken parts; and, in general, any feature which will detract from the serviceability of the sight.

A METHOD FOR PLACING A TELESCOPIC SIGHT ON A GUN TRUNNION.

Make the gun horizontal by a sensitive and accurate level placed on the breech. Clamp securely, but not too tightly, the sight bracket to the right trunnion. Set the sight at 0° elevation and place it in its bracket, making the cross level read zero. Move the bracket until the telescopic level indicates horizontality. Now tightly clamp the bracket, and then drill and tap the trunnion for the screw holes, previously removing the sight. Secure the bracket by its screws. Replace the sight; make the cross level read zero. If the level of the telescope does not read zero, as it should, make it so by filing down the higher V.

The horizontal plane containing the line of sight is now parallel to that containing the axis of the bore.

To bring the line of sight into a vertical plane parallel to that containing the axis of the bore, procure two bars perfectly straight and graduated from about their centers, one to the right and the other to the left. One bar is for the muzzle and the other for the breech. Each bar has sliding on it a sighting piece provided with a vernier scale reading to .001″.

The sighting piece for the breech bar will have a peephole, and that for the muzzle bar preferably cross wires.

The bars are clamped to the breech and muzzle and both made truly horizontal, their zeros being at the center of the bore. The sight should be at zero deflection and its line of collimation truly parallel to the axis of the sight trunnions. Place the sight in the bracket and bring the cross level to zero. Look through the telescope and move the sighting piece on the muzzle bar until the cross wires are cut by the line of sight. Now reverse the sight in its bracket and adjust the cross level. Look through the line of sight and bring the sighting piece on the breech bar until its peephole is cut by the line of sight. If the line of sight is in a vertical plane parallel to that containing the axis of the bore, both graduations should read alike. If not, by filing away equally the right side of one V and the left side of the other, or conversely, depending on the readings, they can be made to read alike.

Another method for bringing the vertical plane of the line of sight parallel to that containing the axis of the bore is as follows: Bring the two sighting pieces until they read alike and are approximately over the telescope. Sight at a point about 4,000 yards distant, using the sighting pieces, and bring the line of sight of the telescope on the same point by filing away equally the side of one V and the left side of the other, or conversely, depending on the position of the distant point with reference to the line of sight.

D. W. FLAGLER,
Brigadier-General, Chief of Ordnance.

OFFICE OF THE CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C., July 14, 1897.

Appendix 21.

REPORT OF PRINCIPAL OPERATIONS AT THE SANDY HOOK PROVING GROUND FOR THE FISCAL YEAR ENDED JUNE 30, 1897.

Sandy Hook Proving Ground,
August 21, 1897.

Sir: I have the honor to submit the following report of the principal operations of this post during the fiscal year ended June 30, 1897:

Firings for experimental and proof purposes have been conducted daily during the year whenever the weather and other circumstances would permit. The object of these firings and the nature and character of the work done at the batteries are summarized in the appended tables. Detailed reports of the results of these firings are not included in this report, as they have already been submitted to the Department from time to time by the Ordnance Board and this office.

MACHINE SHOP.

In connection with the installation of the new machine tools mentioned in my last report, a wing has been added to the machine shop, the central portion of the floor of which is provided with a broad-gauge track connecting with the regular railroad system of the post. Cars containing guns, the heavy parts of carriages, etc., requiring repairs, can now be run directly into the shop for that purpose. The efficiency of the shop is thus greatly increased, and the changes and repairs constantly required in connection with experimental firings and tests can now be effected with much greater promptness and economy than heretofore.

RAILWAY.

The railway pertaining to this post, and by which connection is made with the Central Railroad of New Jersey, continues to be a source of great convenience and economy in the movement of heavy ordnance and the material used by the Quartermaster's Department in building of the new post of Fort Hancock.

During the month of November a heavy easterly gale carried away about 3,500 feet of the narrow neck of sand which had joined the reservation to the mainland of the State of New Jersey. Fortunately the piles of the trestlework built over this neck were driven about 5 feet into clay. This trestlework was therefore in no way injured by the storm. It has, however, been found necessary to extend it 1,350 feet in order to maintain the necessary connections. This work was done at the expense and under the direction of the Quartermaster's Department. A great reduction in the cost of transportation, not only directly but on account of the competition with water transportation, has resulted from the existence of this trestle, fully justifying the expenses incurred in its erection.

ELECTRIC PLANT.

An electric plant for exterior illumination, the lighting of officers' quarters, and for use in connection with experimental firings and tests has been installed at the proving ground under the efficient management of Lieut. George Montgomery, Ordnance Department, assistant proof officer. For the plant there were already on hand a high-speed engine and dynamo, purchased in May, 1895, as a part of an electric hoisting plant. To complete the plant called for the purchase of a storage battery placed in position, wiring of the office and officers' quarters, and the purchase of fixtures.

Charging plant.—The engine is of the high-speed type made by Struthers, Wells & Co., of Warren, Pa., and has a capacity of about 40 horsepower. It is supplied with steam from the same boiler that supplies the machine-shop engine. The regulation of the speed depends on the governor, the engine not being provided with an automatic cut-off. The bedplate of the engine is bolted to a concrete foundation, which replaced one of 12 by 12 inch timbers before the lighting plant was installed. The object of the change was to reduce the vibration to a minimum.

The dynamo is a compound-wound bipolar machine, Thompson-Houston manufacture, and has a capacity of about 44 kilowatts. It has a voltage of 220, but the shunt field is provided with a rheostat of large resistance, which enables the voltage to be reduced and varied for the purpose of charging the storage battery. A switch board of black walnut was made at the proving ground, and has mounted on it a switch for closing the charging circuit and a Weston voltmeter and ammeter for the proper working of the machine. To prevent all possibility of the battery current reversing the polarity of the machine, the series-coil connections were removed, and the dynamo is now worked as a shunt-wound machine. The normal output of the dynamo in charging is 25 amperes at a pressure varying between 160 and 185 volts, depending on the charge in the storage battery. It is readily seen that the maximum output is only a fraction of the capacity of the dynamo.

The dynamo is driven by a belt connection with the engine. Both are located in a small frame building forming an offset to the boiler house.

The charging mains, of No. 6 (B. S. gauge) weatherproof insulated copper wire, carry the charging current overhead a distance of 1,200 feet to the storage battery located in the cellar of the office building. The loss in transmission is about 12 per cent. A 175-volt vibrating bell is placed in the boiler house, one of the charging mains forming one circuit and the ground the other. It forms a means of communication between the battery room and boiler house and saves the time spent in sending a messenger to the boiler house every time it was necessary to stop, start, or alter the charging current.

The storage-battery plant.—This battery was furnished by the Electric Storage Battery Company, of Philadelphia. The battery consisted of 63 capacity cells and 9 counter E. M. F. cells to regulate the pressure in the lighting mains.

Each capacity cell consists of 6 positive plates and 5 negative plates immersed in acid in a glass jar. Each negative plate occupies the space immediately between two adjoining positive plates. The positive plates in each cell are all burned to a common bus bar, and in a similar manner are the negative plates.

Each bus bar has a lug which makes electrical contact with the next lug in the adjoining cell, the positive lug being clamped to the negative one. The positive plates are of lead, formed by rolling up corrugated lead ribbons in a cylindrical form and forcing them into cylindrical holes in the plate itself. The corrugations are to increase the surface on which the acid acts. The negative plates are of lead, but formed by the chloride process. In this process a square-shaped lozenge is formed of a lead chloride and oxide set in a matrix of lead. The process of charging at formation removes the chloride and oxide of lead, giving a large surface for the action of the acid. In the cell the positive and negative plates are kept apart by rubber hairpin separators. The acid used is dilute sulphuric acid having a specific gravity of 1,200 when the cells are fully charged. The process of discharging oxidizes the negative plate and deoxidizes the positive one, and at the same time the acid in the jar, acting on the positive plate, converts it into a lead sulphate. The acid in the jar therefore falls in specific gravity. The process of charging converts the negative plate into pure lead and the positive plate into peroxide of lead, removing the sulphate and therefore raising the specific gravity of the acid.

The counter E. M. F. cells are simply lead plates, having very little capacity, and therefore develop quickly a high electro-motive force. The acid in them is kept at a specific gravity of 1,100. The glass jars rest on sand in wooden trays, and these last are each supported by 4 oil insulators which rest directly on the tables. The oil insulators are in two parts, having a cavity between them which contains the oil. The object of these insulators is to prevent leakage in the battery.

The battery room is provided with 4 wooden tables resting on concrete pillars about 16 inches high. The tables have a thick coating of asphaltum to prevent the action of the acid on the wood. Each of 3 tables carries 22 cells, while the fourth—a smaller one—carries 6.

The battery room is located in the cellar of the office building. It was formerly an unused room, and by putting in a concrete floor and larger windows an ideal battery room was obtained.

An elaborate switch board of marble, black enameled, was placed in position with the battery. This switch board is provided with a Weston voltmeter, a two-way reading Weston ammeter, a three-point switch, a Lewis cut-out switch, a ten-point regulating switch, and a charging and discharging double-pole knife-edge switch. The charging and lighting currents pass through the overload switch—usually set to open at about 35 amperes—and the voltmeter and ammeter give indications for both currents. The Lewis cut-out switch is intended only for charging. It consists of a bridge coil, and a series coil which polarizes the moving part of the switch when the pressure at the terminals of the bridge coil equals the correct amount, the switch closes, and the charging current passes through the series coil, the effect of which is to increase the magnetic pull on the moving part. When the dynamo slows down, the battery pressure exceeds the dynamo pressure, the current reverses through the series coil, demagnetizing the moving part, compelling it to open, thereby breaking the circuit. It generally opens at from 5 to 10 amperes. This switch is an efficient safeguard against injury to the dynamo. The regulating switch maintains the pressure on the lamps at the desired amount by throwing in or out the counter E. M. F. cells. When the battery is fully charged the voltage of each reads about 2.07, and that of the battery will be $63 \times 2.07 = 130.4$ volts. By leaving 9 counter cells in series with the battery the total

pressure is reduced to $130.4-9\times2=112.4$ volts, which is about right for 110-volt lamps, allowing 2 per cent loss in the mains. When the cells are nearly discharged and read about 1.8 the total pressure is $1.8\times63=113.4$ volts, and one counter cell may be left in or thrown out, as 113.4 volts is not an excessive pressure, considering the loss in the lighting mains.

The capacity of the battery is 25 amperes for eight hours. The voltage of the lamps is 110; and they demand about one-half ampere per lamp of 16 candlepower. The number of 16-candlepower lights that can be maintained for eight hours is, therefore, $\frac{25}{1/2}$, or 50. The capacity of the battery is such as to give sufficient light for two winter evenings, without charging.

Besides lighting, the battery is used in the office for the call bells, the annunciator, the anemometer, and the Boulengé chronographs, as well as for firing and testing purposes. It enables us to dispense entirely with the primary batteries, which had been used exclusively for these purposes. The storage-battery cells, on account of their internal resistance being negligible and having a constant voltage for small currents, furnish the very best type of cell for the chronographs, or, in fact, for any work in which an absolutely constant current is essential.

Each Boulengé chronograph is provided with a group of four cells in the battery, and the resistance of the wires is made so small that it enables the current for both registrar and chronometer to pass through a make-and-break switch near the instrument. This switch breaks the currents in both the registrar and chronometer simultaneously, eliminating any error in the time of disjunction, except that due directly to the magnets themselves, and replaces the disjunctor, which had always been a source of error.

It is intended to use the battery for operating the shutter in the Squier photochronograph, and such cells of it as may be desired for operating the circuits.

The battery wiring is done entirely with No. 6 copper wire, okonite insulation.

The maintenance of the battery is trifling compared with a primary one. About twice a week the cells are refilled with water to replace loss by evaporation, and to maintain the specific gravity at 1,200.

It is very seldom that the cells demand any acid. Readings are taken of each cell with a low-reading voltmeter, at the completion of the charge, and usually about twice a week. It is only in case of a cell sulphating from an overdischarge or an accidental short circuit that great care and attention are demanded; and such condition can not obtain if the battery is worked within reasonable limits and the cells are kept clear of foreign material.

The wiring and fixtures.—At the terminals of the discharging switch on the switch board in the battery room are the lighting mains for the office and officers' quarters. The office mains, of No. 12 copper wire, Grimshaw white-core insulation, lead to a double-pole knife-edge switch, with fuse and mounted in a slate-lined box, and from the terminals of this switch to the first floor, where the cut-out box is located. From the cut-out box proceed four separate lighting circuits of the same size wire which feed the lamps directly. In the cellar and on the walls the wires are carried in hard-wood molding, and on the ceiling they are carried in porcelain cleats.

The lighting mains for supplying the officers' quarters are lead-covered insulated cables No. 0, the conductor being stranded. They are

carried under ground, each cable in a 2-inch pipe, for a distance of 400 feet. They lead directly to a double-pole knife-edge switch, with fuse, in the cellar of the officers' quarters, and which controls the lights in that building. From this switch two mains of No. 3 insulated copper wire, in brass-covered conduits, carry the current to a cut-out box on the second floor. Eight lamp circuits leave this box and feed the lamps directly. The wiring in the officers' quarters is all of No. 12, Grimshaw white-core insulated copper wire, and each is carried in a single circular loom tube. The tubing is completely concealed. The cut-outs are all double pole, of porcelain, and, like the controlling switch, are mounted on slate. The size of the wire and the distribution of the lamps on the different circuits are such that the drop in potential, from the cut-out box to the farthest lamp, with all the lamps burning, is less than 2 per cent. The chandeliers in the vestibule and halls are controlled by Cutter flush switches. The wiring for the hall lights on the first and second floors is such that it enables one in either hall to turn on or off both lights simultaneously, a feature of great convenience.

With the exception of the hall light, which is a bracket fixture, and one wall socket light in the cellar, drop lights are entirely used in the office. The lamp cords are suspended from the rosette cut-outs screwed to the ceiling, and attached to Edison sockets.

The cellar of the officers' quarters is provided with drop-cord lights, but the rest of the building is furnished with electroliers and brackets in antique brass, fitted for Edison sockets.

Two exterior lights, one in front of the office and the other in front of the officers' quarters, are supplied from lead-covered insulated wires placed under ground and controlled, one from the office and the other from the officers' quarters.

The number of 110-volt lamps required are 62 for the officers' quarters, 22 for the office, and 2 for exterior lighting. The total number is 86.

Maintenance of the system.—The maintenance of the system calls for no additional labor. The engine and dynamo are attended to by the same man who fires the boiler and manages the shop engine. The enlisted man who formerly attended to the primary batteries now has charge of the storage battery plant. A watchman, in addition to his other duties, attends to the 10-point regulating switch, which demands only about three visits in the evening. The cost of the maintenance is therefore only the cost of the coal, the replacement of lamps, and repairs.

The efficiency of the dynamo is 85 per cent; the average horsepower exerted by the engine will be $\frac{170\times25}{.85\times746}=6.7$ during the time of charging, averaging about three hours. The coal consumption is about 3 pounds per horsepower per hour, which will amount to about 10 tons of coal in the year at a cost of $44. Burned-out lamps, broken glass jars, can be replaced, and other repairs made at a trifling additional expense. Under the conditions prevailing at this post, therefore, this electric plant fulfills all requirements in a more economical and efficient manner than by any other method that could be adopted for the purpose.

Very respectfully, your obedient servant,

FRANK HEATH,
Captain, Ordnance Department, U. S. A., Commanding.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

(9838—Enc. 22)

Statement showing kind and weight of United States property received at and shipped from the Sandy Hook Proving Ground by the Government railroad extending from Sandy Hook to Highland Beach, New Jersey, length 6 miles.

Total received for Ordnance Department ....pounds..	6,737,956
Total received for life saving service ....do....	89,600
Total received for Quartermaster's Department.....................cars..	[1] 295
Total shipped for Quartermaster's Department......................do....	[1] 5
Total shipped for Ordnance Department.........................pounds..	3,359,895
Total movement...pounds..	10,187,451
Total movement..cars..	[1] 300

Number of cars loaded with United States property upon which the Government paid the transportation charges................................		96
Number of cars loaded with United States property upon which the contractors paid the transportation charges:		
For the Ordnance Department..................................	145	
For the Quartermaster's Department	300	
For the Life Saving Service....................................	4	
		449
Total movement of cars..		545

FRANK HEATH,
Captain, Ordnance Department, U. S. A., Commanding.

(9838—Enc. 23)

TABLE I.

[Rounds given in bold-faced figures show that they were fired for two objects. These rounds are not counted in the total for the gun.]

Object of firing.	Rapid-fire guns, breech-loading.		Siege rifles and howitzers, breech-loading.		Total rounds for object of firing.
	4.7-inch Seabury.	4.7-inch Gerdom.	5-inch service.	7-inch service.	
Proof of gun....................................	1	....	64	77	142
To obtain data for range	....	....	4	....	4
Test of -					
Breech mechanism	....	29	....	....	29
Frankford Arsenal shrapnel, 5-inch..........	....	....	8	....	8
Frankford Arsenal shrapnel, 7-inch..........	....	....	....	8	8
Platform for siege-gun carriages	....	....	39 **80**	6 **51**	176
Du Pont's sphero-hexagonal powder	....	....	18 **12**	....	30
Maxim smokeless powder....................	....	....	2	....	2
Du Pont's smokeless powder................	....	....	....	4	4
The efficiency of frozen dynamite..........	....	....	....	4	4
Gun for accuracy	....	....	10	....	10
Five-inch service siege carriage..............	....	....	12 **35**	....	47
Total for gun..................................	1	29	157	99	....

[1] Building materials, weights unknown.

TABLE II.—*Field guns, breech-loading, rifled, steel.*

[Rounds given in bold-faced figures show that they were fired for two objects. These rounds are not counted in the total for the gun.]

Object of firing.	6-pounder.		75-mm. Hotchkiss No. 1639.	3.2-inch.						3.6-inch, No. 13.	Total rounds for object of firing.
	Driggs No. 10.	Driggs No. 1.		No. 1.	No. 18.	Seabury No. —.	Fletcher No. —.	Dashiell No. —.	Gerdom No. 2.		
Test of—											
Smokeless powders—											
For ballistic uniformity						5	11	10	42		68
After cold storage						5	6	10	9		30
With moisture						11	20	15	15		61
After cold storage of **cart**ridges						5	5				10
After wetting						5	4	5	5		19
After heating						20	30	35	24		109
Laflin & Rand's smokeless **powders**									12		12
Volney's smokeless powder		5									5
Maxim smokeless powder		17							29		46
Du Pont's smokeless powder		30				6		4	14		54
Common shell	18										18
Detonators for high explosives		15									15
Field carriages	**44**		57								101
Fixed ammunition	10										10
Steel armor-piercing shell	16										16
Waterproof covers for car**tridges**				9				12	68		89
Driggs's limited recoil field **carriage**					38						38
Frankford Arsenal shrap**nel, 3.6-**inch										20 **6**	26
Frankford Arsenal shrap**nel, 3.2-**inch									20 **6**		26
American Ordnance Com**pany's** shrapnel, 3.2-inch									64 **29**		93
Gerdom gun for endurance									300 **234**		534
Extractor in Gerdom gun									1		1
New design in metallic car**tridge c**ases									8		8
Hotchkiss gun for accuracy			20								20
Gun with defective car**tridges**							8	3	17		28
Gun with excessive pres**sures**								10	10		20
Gun with dust								5	10		15
Gun with rust									10		10
To determine—											
Charge	**10**						4	2	10		26
Velocity and charge for 18¼-**pound p**rojectile									18		18
Effect of position of band **on the a**ccuracy of fire									123		123
The temperature of bore									100		100
Exhibition before the Chief of **Ordnance, U**. S. Army									5		5
Total for gun	44	67	77	9	38	57	88	111	914	20	

TABLE III.—*Breech-loading rifled mortars.*

[Rounds given in bold-faced figures show that they were fired for two objects. These rounds are not counted in the total for the gun.]

Object of firing.	Steel.		12-inch cast iron.		12-inch steel.		Total rounds for object of firing.
	3.6-inch No. 3.	7-inch No. 1 type.	Service.	No. 1 type.	Service.	No. 1 type.	
Test of—							
Peirce delayed-action fuse for high explosives				1			1
Spring-return mortar carriage, model 1896					10		10
Midvale steel deck-piercing shell					4	4	8
Midvale steel torpedo shell					2	4	6
Du Pont's smokeless powder	26	26			6	3	61
Du Pont's brown prismatic powder					4	4	8
Carriage and siege platform		27					27
Du Pont's sphero-hexagonal powder						3	3
To obtain data for range table	42		15				57
To determine range	22				102		124
To obtain targets						37	37
To determine suitability of smokeless powder for mortar	64	46					110
Exhibition before the Chief of Ordnance, U. S. A						1	1
Test of Farcot-Fletcher breech mechanism						39	39
Total for mortar	90	99	15	1	128	58	

TABLE IV.—*Seacoast guns.*

[Rounds given in bold-faced figures show that they were fired for two objects. These rounds are not counted in the total for the gun.]

Object of firing.	Muzzle-loading 15-inch smoothbore, No. 118.	Muzzle-loading rifles.		Breech-loading rifles.					Total rounds for object of firing.
		8-inch converted, No. 33.	7-inch Ames, No. 7.	8-inch Haskell Multicharge.	8-inch West Point Foundry, No. 1 type.	8-inch service.	10-inch service.	12-inch service.	
Proof of guns						16	79	28	123
Test of—									
Du Pont's brown prismatic powders							5 7	2 10	24
Du Pont's smokeless powders							5		5
Laflin & Rand's smokeless powders						4			4
Du Pont's smokeless powder .30-caliber rifle for safety			4						4
Emmensite for safety			3						3
Du Pont's sphero-hexagonal powders	11	3							14
Haskell multicharge gun				2					2
Carpenter armor-piercing steel shot								7 6	13
Disappearing carriages							33 37	14 7	91
Breech mechanism								19	19
Midvale armor-piercing steel shot						5	6 16		27
Gun cotton for safety			4		4				8
United States Projectile Co.'s steel shell						1			1
Du Pont's smokeless powder for shell-bursting charge			1						1
Peirce delayed action detonating fuse for high explosives			9						9
Experimental parapet						4	3	3	10
Rapidity test before the board for testing rifled cannon								15	15

TABLE IV.—*Seacoast guns*—Continued.

Object of firing.	Muzzle-loading 15-inch smoothbore, No. 118.	Muzzle-loading rifles.		Breech-loading rifles.					Total rounds for object of firing.
		8-inch converted, No. 33.	7-inch Ames, No. 7.	8-inch Haskell Multi-charge.	8-inch West Point Foundry, No. 1 type.	8-inch service.	10-inch service.	12-inch service.	
To determine—									
Range for the information of committee on high explosives of the Board of Ordnance and Fortification						3			3
The relative accuracy of service and capped projectiles							11		
Total for gun	11	3	17	2	4	29	137	88	

TABLE V.—*Tests in explosion chamber and sand.*

	Number.
Fired in explosion chamber:	
8-inch steel shell containing—	
3 pounds 12 ounces gun cotton	2
4 pounds 7 ounces Du Pont's caliber .30 smokeless powder	1
7-inch steel shell containing—	
5 pounds 8 ounces Du Pont's caliber .30 smokeless powder	1
2 pounds 6 ounces gun cotton	1
5 pounds 8 ounces gun cotton	2
Exploded in iron cylinder:	
3.2-inch Frankford Arsenal steel shrapnel	8
3.6-inch Frankford Arsenal steel shrapnel	8
3.2-inch American Ordnance Company's steel shrapnel	24
Exploded in sand on top of steel plate:	
12-inch steel shell containing—	
82 pounds Emmensite	1
74 pounds 8 ounces Du Pont's smokeless powder, caliber .30	1
Total	49

VI.

To determine the remaining velocity of caliber .30 bullet at ranges of 1,000 and 1,500 yards, 380 rounds.

VII.

GUNS[a] PROVED.

	Number of guns.
Breech-loading, rifled, steel:	
5-inch	9
7-inch	11
8-inch	2
10-inch	12
12-inch	4

[a] Watervliet Arsenal.

Recapitulation.

	Number of rounds.
From muzzle-loading seacoast guns	31
From breech-loading seacoast guns	260
From rapid-fire guns	30
From siege rifles and howitzers	256
From field guns	1,425
From mortars	391
From caliber .30 rifle	380
From explosion chamber and sand	49
Grand total	2,822

FRANK HEATH,
Captain, Ordnance Department, U. S. A., Commanding.

APPENDIX 21*a*.

SUMMARY OF TESTS OF POWDERS AT SANDY HOOK PROVING GROUND.

SANDY HOOK PROVING GROUND,
October 20, 1897.

SIR: I have the honor to submit the following summary of tests of powders furnished under contract with the Department or for experimental purposes during the fiscal year ended June 30, 1897:

During the year firings have been conducted with powders furnished by the Maxim Powder and Torpedo Company, the California Powder Works (Peyton smokeless powder), the Laflin & Rand Powder Company, the Messrs. Du Pont, and Dr. Volney. The objects of these firings have been to determine the ballistic qualities of the various samples submitted, these samples differing from each other in the formula used in their composition, and the form and size of grain. Various kinds of smokeless powders were also used in tests of types of 3.2-inch rifles, and incidentally were subjected to heat and cold, moist and dry air, respectively, before test.

Guns of the following calibers have been used in the tests, viz: 6-pounder, 3.2-inch, 5-inch, 7-inch howitzer, 7-inch mortar, 8-inch, 10-inch, and 12-inch rifle, and 12-inch mortar. In the tables submitted herewith the results are separated according to the calibers of the guns and the objects of firings, the samples furnished by the different manufacturers being placed in separate groups of tables.

MAXIM-SCHUPPHAUS POWDER.

The tests of this powder have been confined to samples for the test of a Gerdom 3.2-inch rifle, using metallic ammunition; the 6-pounder, and two rounds from the 5-inch rifle. The powder is no longer manufactured under this name.

3.2-INCH B. L. RIFLE, STEEL, GERDOM NO. 2, MODEL 1896.

Date.	Charge.	Projectile.	Velocity.	Pressure.	Remarks.
1896.	*Ounces.*	*Pounds.*	*Feet.*	*Pounds.*	
July 9	22	16.5	1,495	23,380	Maxim smokeless, composition "A." Object, to determine charge. These rounds were fired from powder stored in the original box sent by the manufacturer.
	22	16.5	1,496	24,800	
	9	Lot 1, 1896.			
	8¾	Received Apr. 12, 1895.			
	17¾	16.5	1,485	29,320	
	8½	Lot 1, 1896.			
	8½	Received Apr. 12, 1895.			
	17	16.5	1,444	27,718	
	22	16.5	1,498	24,960	These two rounds were fired from powder stored in air-tight boxes since Aug. 19, 1895. Prior to that it was stored in the original boxes sent by the manufacturer. Received Apr. 12, 1895.
	22	16.5	1,492	25,582	

3.2-INCH B. L. RIFLE, STEEL, GERDOM NO. 2, MODEL 1896—Continued.

Date.	Charge.	Projectile.	Velocity.	Pressure.	Remarks.
1896.	*Ounces.*	*Pounds.*	*Feet.*	*Pounds.*	
July 10	8¾	Received Apr. 2, 1895.			
	8⅛	Lot 1, 1896.			
	17⅜	16.5	1,378	24,800	Maxim smokeless, for ballistic uniformity, composition "A."
	a 17⅜	16.5	1,416	26,964	
	a 17⅜	16.5	1,418	27,580	
	a 17⅜	16.5	1,422	27,800	
	a 17⅜	16.5	1,422	27,340	
	a 17⅜	16.5	1,419	27,460	
	a 22	16.5	1,429	27,655	
	a 22	16.5	1,429	28,120	
	a 22	16.5	1,422	27,945	
July 13	17⅛	16.5	1,444	28,240	Maxim smokeless, composition "A." Cold-storage test. The powder for this test was kept in a refrigerator for 2 days, then fixed cold, and fired.
	17⅛	16.5	1,425	24,620	
	17⅛	16.5	1,442	28,880	
	17⅛	16.5	1,439	28,360	
July 14	17⅛	16.5	1,428	26,891	A moisture test of same powder. The powder was kept for 3 days in a closed vessel saturated with moisture from a dish of water contained in it and then fired without drying.
	17⅛	16.5	1,433	26,891	
	17⅛	16.5	1,429	27,800	
	17⅛	16.5	1,428	27,600	
	17⅛	16.5	1,426	27,936	
July 15	17⅛	16.5	1,472	30,060	A wetting test of same powder. The powder was dipped in water and subsequently dried in the sun. The period of dipping was about 15 hours, and that of exposure to the sun 13 hours.
	17⅛	16.5	1,473	30,120	
	17⅛	16.5	1,475	31,180	
	17⅛	16.5	1,469	31,000	
July 17	17⅛	16.5	1,437	27,520	A heat test of same powder. The powder was kept in a closed box for about 7 days, exposed to a temperature from 100° to 120° F. It was then allowed to cool for about 16 hours and then fired.
	17⅛	16.5	1,438	27,020	
	17⅛	16.5	1,492	30,600	A heat test of same powder. This powder was put in cartridge cases exposed to a temperature of 100° to 120° F. for 7 days and fired hot. Temperature at commencement of firing, 97° F.
	17⅛	16.5	1,496	32,060	
July 18	17⅛	16.5	1,417	26,260	A moisture test of same powder. The powder was tested by exposing it in a closed box to air saturated with moisture from a dish of water. The time of exposure was 7 days, at the expiration of which the powder was fired.
	17⅛	16.5	1,415	26,320	
July 24	17⅛	16.5	1,413	25,760	A moisture test of same powder. The powder was placed in a closed box and in air saturated with moisture from a dish of water contained in the box. The time of exposure was 14 days, when the powder was taken out and fired without drying.
	17⅛	16.5	1,416	26,520	
July 18	13¾	16.5	1,412	30,840	Maxim smokeless, lot 2, 1896 ⟨N⟩. The powder has the same grain and composition as lot 1, 1896.
	13¾	16.5	1,417	31,069	
Aug. 14	10	16.5	917	—14,000	Maxim-Schupphaus smokeless, formula No. 11, die No. 2 B, length ½ inch. This powder was submitted as a pure cotton one. The grain is the usual Maxim one—length, ½ inch; diameter, 1/16 inch, and pierced by 7 holes throughout its length. Color, chocolate brown. In appearance the powder does not differ from the usual smokeless powder submitted by the company for the 3.2-inch field gun. The discharge gave rise to a light gray smoke and about the average in volume.
	13	16.5	1,217	—14,000	
	16	16.5	1,329	22,860	
	17½	16.5	1,420	27,710	
	18	16.5	1,465	30,680	
	17¾	16.5	1,439	28,220	
	17¾	16.5	1,434	27,800	
	17¾	16.5	1,440	28,300	
	17⅛	16.5	1,485	31,580	A heat test of powder, Maxim smokeless, composition "A." This powder was kept in a closed box at a temperature of 100° to 120° F. for 15 days, and then fired hot.
	17⅛	16.5	1,473	29,160	
Aug. 20	15	16.5	1,466	31,400	Maxim smokeless for 3.2-inch gun, lot 3, 1896. This powder is of the ordinary composition of the Maxim smokeless powder for this gun, but of a new granulation designed to be more suitable. The length of the grain is ½ inch. The die is designated as 2 B, and the formula No. 82a. Color of the powder is a chocolate brown.
	14½	16.5	1,434	30,460	
	14½	16.5	1,432	30,680	
	14⅛	16.5	1,428	29,870	
Oct. 20	12	16.5	1,243	20,640	Maxim-Schupphaus smokeless, die No. 2 B, ½ inch in length. The grains of this powder are cylindrical, about ½ inch long and 3/16 inch in diameter. The cylinders are pierced with 7 holes in the direction of their length. Color, brown.
	14½	16.5	1,444	30,440	
	14¼	16.5	1,454	31,400	
	14	16.5	1,421	29,160	

a Proportioned as in preceding round.

3.2-INCH B. L. RIFLE, STEEL, GERDOM NO. 2, MODEL 1896—Continued.

Date.	Charge.	Projectile.	Velocity.	Pressure.	Remarks.
1896.	*Ounces.*	*Pounds.*	*Feet.*	*Pounds.*	
Nov. 14	15	16.5	1,398	24,840	Maxim smokeless, ballistite No. 2 B ⟨R⟩; granulation, 1,486. The shape of the grain is like the ordinary Maxim. Length, ¼ inch; diameter, ⅛ inch, and is pierced with 7 longitudinal holes. Color, brown, and is slightly translucent, but not as much as previous samples of ballistite.
	15¾	16.5	1,449	27,480	
	15½	16.5	1,431	26,870	
	15½	16.5	1,434	27,210	
	15½	16.5	1,451	27,870	
1897. Jan. 11	13	16.5	1,294	21,240	Maxim smokeless, ballistite ⟨S⟩. The grains of this powder are cylindrical, about ¼ inch long and 0.2 inch in diameter. The cylinders are pierced with 7 holes in the direction of their length. Color, brown.
	15	16.5	1,426	26,620	
	15¾	16.5	1,483	31,490	
	15⅞	16.5	1,454	28,620	
May 4	15	18.25	1,408	29,690	
	15¾	18.25	1,427	30,540	Maxim smokeless, lot 2, 1897. To obtain a charge of powder to give 1,600 feet per second, muzzle velocity, using an 18¼-pound projectile.
	16¼	18.25	1,463	32,040	
	16⅛	18.25	1,465	30,580	
	16¾	18.25	1,484	31,270	
	17¼	18.25	1,526	34,780	
	14	18.25	1,311	28,160	No. 82ᵃ, P. 2 B ⟨K⟩. Powder intended fo the 6-pounder Driggs.
	23	18.25	1,284	28,000	82ᵃ, die No. 32, for 6-pounder gun.
	27	18.25	1,497	28,140	
	29	18.25	1,635	32,640	
	25	18.25	....	39,100	Maxim-Schupphaus smokeless, No. 82, M. P., 3 die ⅛ inch for 5-inch rifle.
	23	18.25	1,627	33,140	
	22⅛	18.25	1,567	30,080	
	22⅜	18.25	1,607	32,260	
	22¾	18.25	1,561	30,140	
	22⅞	18.25	1,596	31,940	
1896. Aug. 25	11½	6	1,673	−28,000	Maxim smokeless, 82ᵃ, No. 3 B, length ⅛ inch. This powder has the usual composition and perforated grain of the Maxim smokeless powder. The color of the grain is a chocolate brown. Upon discharge the powder gave rise to very little smoke.
	13	6	1,873	−28,000	
	14½	6	2,031	−28,000	
	16	6	2,189	30,660	
Aug. 26	16½	6	2,244	32,700	
	16½	6	2,223	33,910	
	16½	6	2,242	35,400	
	16½	6	2,243	34,290	

6-POUNDER DRIGGS-SCHROEDER R. F. GUN.

Date.	Charge.	Projectile.	Velocity.	Pressure.	Remarks.	
Oct. 29	20	6	2,096	26,280	Formula No. 82ᵃ, die 32	Schupphaus smokeless.
	22	6	2,349	35,533	Formula No. 82ᵃ, die 32	
	20	6	2,348	35,111	Formula No. 82ᵃ, die 3 A	
	22	6	2,337	34,400	Die 32	
	20	6	2,333	34,383	Die 3 A	
	22	6	2,320	34,156	Die 32	
	20	6	2,304	33,745	Die 3 A	

The grains of this powder (formula No. 82ᵃ, die No. 32) are cylindrical, about ¼ inch long and 0.275 inch in diameter. They are pierced in the direction of their length by 7 holes. The color is brown.

The grains of this powder (formula No. 82ᵃ, die No. 3 A) are cylindrical, about ¼ inch in length and 0.625 inch in diameter. They are pierced in the direction of their length by 7 holes. The color is brown.

5-INCH B. L. RIFLE, STEEL, NO. 16.

Date.	Charge.	Projectile.	Velocity.	Pressure.	Remarks.
1896.	*Pounds.*				
Aug. 21	9	45	2,275	32,060	Maxim-Schupphaus smokeless, 82ᵃ, die No. 4, for 5-inch rifle. The grains of this powder are cylindrical; length, 1¼ inches; diameter, 11/16 inch, and pierced by 7 holes in the direction of its length. The color is a chocolate brown.
	9¼	45	2,375	34,067	

PEYTON SMOKELESS POWDER.

This powder is manufactured by the California Powder Works. It has been used during the year in the test of a Fletcher 3.2-inch rifle, using metallic ammunition.

3.2-INCH B. L. RIFLE, FLETCHER R. F. GUN.

Date.	Charge.	Projectile.	Velocity.	Pressure.	Remarks.
1896.	*Ounces.*	*Pounds.*	*Feet.*	*Pounds.*	
July 9	16½	16.5	1,442	30,060	To determine charge of Peyton smokeless powder, composition "B."
	16¼	16.5	1,448	28,680	
	16	16.5	1,439	27,400	
	16⅛	16.5	1,433	27,764	
July 13	16⅛	16.5	1,451	27,900	Same as above. Test for ballistic uniformity.
	16⅛	16.5	1,451	28,400	
	16⅛	16.5	1,452	28,360	
	16⅛	16.5	1,453	28,420	
	16⅛	16.5	1,456	28,200	
	16	16.5	1,438	28,020	A cold-storage test of powder, Peyton smokeless, composition "B." The powder for this test was kept in a refrigerator for 2 days, and then fixed cold and fired.
	16	16.5	1,438	28,300	
	16	16.5	1,432	27,320	
	16	16.5	1,429	26,836	
	16	16.5	1,445	27,964	
July 14	16	16.5	1,438	27,964	A moisture test of same powder. The powder was kept for 3 days in a closed vessel saturated with moisture from a dish of water contained in it, and then fired without drying.
	16	16.5	1,428	27,636	
	16	16.5	1,435	28,240	
	16	16.5	1,426	27,782	
	16	16.5	1,437	27,945	
July 15	16	16.5	1,523	35,820	A wetting test of same powder. The powder was dipped in water, subsequently dried in the sun. The period of dipping was about 15 hours, and the exposure to the sun 13 hours.
	16	16.5	1,516	34,620	
	16	16.5	1,516	34,740	
July 17	16	16.5	1,446	26,340	A heat test of same powder. This powder was kept in a closed box for about 7 days, exposed to a temperature from 100° to 120° F. It was then allowed to cool for about 16 hours and then fired.
	16	16.5	1,449	27,580	
	16	16.5	1,471	28,760	A heat test of same powder. This powder was put in cartridge cases and exposed to a temperature of 100° to 120° F. for 7 days, and then fired hot.
	16	16.5	1,476	29,340	
July 18	16	16.5	1,398	26,020	A moisture test of same powder. This powder was tested by exposing it in a closed box to air saturated with moisture from a dish of water. The time of exposure was 7 days, at the expiration of which the powder was fired.
	16	16.5	1,408	26,220	
July 24	16	16.5	1,386	25,060	A moisture test of the same powder. This powder was placed in a closed box and in air saturated with moisture from a dish of water contained in the box. The time of exposure was 14 days, when the powder was taken out and fired without drying.
	16	16.5	1,391	25,640	
	15¾	16.5	1,405	24,240	A moisture test of Du Pont's smokeless powder, lot 1, 1896, composition "D." Remark: Same as preceding.
	15¾	16.5	1,421	25,960	
July 25	16	16.5	1,468	29,890	A heat test of powder, Peyton's smokeless, composition "B." This powder was kept in a closed box at a temperature of 100° to 120° F. for 15 days, and then fired hot.
	16	16.5	1,468	30,080	
	15¾	16.5	1,467	29,400	A heat test of powder, Du Pont's smokeless, lot 1, 1896, composition "D." Remark: Same as preceding.
	15¾	16.5	1,470	29,360	

AMERICAN SMOKELESS POWDER.

This powder is now manufactured by the Laflin & Rand Powder Company. Firings with this powder have been made only with the 3.2-inch rifle, using metallic ammunition, and the 8-inch B. L. rifle.

3.2-INCH GERDOM.

Date.	Charge.	Projectile.	Velocity.	Pressure.		Remarks.
1897.	*Ounces.*	*Pounds.*	*Feet.*	*Pounds.*		
Apr. 19	16	16.5	1,129	15,200		Laflin & Rand's smokeless W.-A., formula No. 118, NN (13.0-10). Granulation, tubular, $\frac{8-4}{32}$. This powder is cylindrical, having a single central hole. Composition, NN(13.0-10).
	18	16.5	1,254	19,400		
	20	16.5	1,379	22,900		
	21	16.5	1,444	25,360		
May 28	16	16.5	1,460	26,660	⅝ inch long…	Laflin & Rand's smokeless W.-A. for 3.2-inch rifle NN (13.0-10). Formula No. 118. The grains of this powder are cylindrical and pierced with a central hole. The diameter of the grain is about 0.15 inch and is quite uniform. The color is light brown and the powder has a homogeneous structure. The grains are brittle.
	15¾	16.5	1,437	26,820		
	16¼	16.5	1,427	24,000	5¾ inches long	
	16¼	16.5	1,427	23,000		
	16	16.5	1,406	22,160	4¼ inches long	
	15¾	16.5	1,430	25,750		
	15¾	16.5	1,438	26,990	⅝ inch long…	

8-INCH B. L. RIFLE, STEEL, No. 29.

Date.	Charge.	Projectile.	Velocity.	Pressure.	Remarks.
1896.	*Pounds.*				
Sept. 17	50	301	1,452	14,256	Laflin & Rand's smokeless, W.-A. The grains of this powder are hollow cylinders, about 22 inches in length; outside diameter, ¾ inch; inside diameter, about ¼ inch. The color is a seal brown. After each discharge there was a large quantity of very light gray smoke. It was found impossible to thoroughly clean the bore with water and sponge after firing with this powder. A coating of slate color was left after washing. This can only be removed by scraping. Only part of the fouling on the mushroom head could be removed by washing. The deposit was of a brilliant black color, and can only be removed by scraping. The bore and mushroom head were coated with cosmic before the gun was fired. The magazine sergeant complained of a slight nitroglycerin headache after putting up this powder.
	80	301	2,113	30,990	
	85	301	2,400	40,617	
	82	301	2,267	37,000	

DR. VOLNEY'S POWDER.

An experimental sample of smokeless powder furnished by Dr. Volney, of New York City, was fired with the following results:

6-POUNDER DRIGGS-SCHROEDER R. F. GUN.

Date.	Charge.	Projectile.	Velocity.	Pressure.	Remarks.
1896.	*Ounces.*	*Pounds.*	*Feet.*	*Pounds.*	
July 24	12	6	1,850	20,800	Dr. Volney's smokeless for 6-pounder gun. The increased pressure and velocity were due to the inventor putting up a charge composed of thinner sheets than those used in the other rounds. This powder came in sheets about 10 inches long, ¼ inch thick, and of varying widths. It can be rolled up, and in that condition it is placed in the cartridge case. The interior of the folded sheets has a sheet of thinner powder to act as an igniter, and was claimed to be a substitute for the black-powder igniter. Each sheet of the powder is composed of two layers, one being darker and denser than the other. The color of the powder is green, and appears to consist of light green particles interspersed in a more decided green matrix, giving the powder a speckled appearance. The composition, given by the inventor, is 50 per cent gun cotton, 30 per cent ammonium picrate, and 20 per cent nitroglycerin. Handling the powder discolors the hands in the same way that a handling of picric acid, or its compounds, does. The powder bears a stronger resemblance to French B.N. than any other powder tested here.
	14	6	2.252	39,120	
	13	6	2,066	32,340	
	12⅞	6	2,204	39,420	
	12⅞	6	2,017	28,000	

DU PONT'S POWDERS.

Powders of all varieties—brown prismatic, black sphero-hexagonal, and smokeless—have been supplied by this company under contract with the Department. The smokeless powders were used in the test of the Dashiell and Seabury 3.2-inch rifles, and samples of smokeless powders furnished by this company for the service .30-caliber rifle were fired with good results from the 3.6-inch B. L. mortar.

Brown prismatic powder.

12-INCH B. L. MORTAR, STEEL, NO. 8.

Date.	Charge.	Projectile.	Velocity.	Pressure.	Remarks.
1896.	*Pounds.*	*Pounds.*	*Feet.*	*Pounds.*	
Oct. 15	90	800	1,077	27,773	Du Pont's brown prismatic, sample 2C, 1896.
	95	800	1,116	31,925	

12-INCH B. L. MORTAR, STEEL, TYPE.

Date.	Charge.	Projectile.	Velocity.	Pressure.	Remarks.
Dec. 21	90	800	1,021	22,160	Du Pont's brown prismatic, sample 2D, 1896.
	109	800	1,111	27,800	
	116	800	1,158	31,840	
1897.					
Jan. 4	90	800	1,021	23,470	Du Pont's brown prismatic, sample 2E, 1896.
	105	800	1,104	28,440	
	110	800	1,148	30,620	
Mar. 15	50	800	788	19,990	Du Pont's sphero-hexagonal, sample 1A, 1897, for siege guns and 12-inch mortars.
	52	800	817	22,180	
Mar. 29	55	800	839	22,500	Du Pont's sphero-hexagonal, sample 1B, 1897, for siege guns and 12-inch mortars.

12-INCH B. L. RIFLE, STEEL, NO. 19.

Date.	Charge.	Projectile.	Velocity.	Pressure.	Remarks.
Mar. 11	360	1,000	1,688	25,818	Du Pont's brown prismatic, sample 1A, 1897.
	460	1,004	1,936	35,650	
Mar. 13	475	1,003	1,990	41,867	
Mar. 25	475	1,003	1,923	37,057	Du Pont's brown prismatic, sample 2, 1897. This powder was not entirely consumed. Unburned grains found in front of gun, and some were embedded in the timbers of the oak backing, 150 feet from gun.
	490	1,005	1,940	37,206	

12-INCH B. L. RIFLE, STEEL, NO. 14.

Date.	Charge.	Projectile.	Velocity.	Pressure.	Remarks.
May 12	475	1,003	2,088	48,519	Du Pont's brown prismatic, sample 3, 1897.
	430	1,002	1,974	43,178	

12-INCH B. L. RIFLE, STEEL, NO. 16.

Date.	Charge.	Projectile.	Velocity.	Pressure.	Remarks.
1896.					
Aug. 19	460	1,000	2,002	39,312	Du Pont's brown prismatic, sample 1B, 1896.
	450	1,001	1,964	39,210	

12-INCH B. L. RIFLE, STEEL, NO. 17.

Date.	Charge.	Projectile.	Velocity.	Pressure.	Remarks.
Sept. 23	385	1,003	1,777	29,586	Du Pont's brown prismatic, sample 1C, 1896.
	450	1,003	1,962	39,622	
	450	1,004	1,956	37,688	
	450	1,001	1,943	37,326	

12-INCH B. L. RIFLE, STEEL, No. 18.

Date.	Charge.	Projectile.	Velocity.	Pressure.	Remarks.
Oct. 29	470	1,005	1,930	38,142	Du Pont's brown prismatic, sample for 12-inch rifle. A number of unburned grains found in front of gun.
	470	1,004	1,894	35,139	

Brown prismatic powder—Continued.

10-INCH B. L. RIFLE, STEEL, No. 41.

Date.	Charge.	Projectile.	Velocity.	Pressure.	Remarks.
1896.	*Pounds.*	*Pounds.*	*Feet.*	*Pounds.*	
Aug. 21	260	572	1,957	33,976	Du Pont's brown prismatic, sample 2A, 1896.
	270	577	1,973	37,167	
	280	579	2,004	37,706	
Oct. 1	250	577	1,925	33,378	Du Pont's brown prismatic, sample 2B, 1896.
	270	577	1,990	38,035	
	270	576	1,999	36,479	
Oct. 13	250	576	1,913	33,020	Du Pont's brown prismatic, sample 2C, 1896.
	270	576	1,976	36,600	
Oct. 15	276	575½	2,010	39,879	
	273	575	1,992	36,696	

5-INCH B. L. RIFLE, STEEL, NO. 18.

1897.					
Mar. 13	12	45	1,735	35,000	Du Pont's sphero-hexagonal, sample 1A, 1897, for 5-inch rifle and 12-inch mortar.
Mar. 29	12	45	1,794	36,310	Du Pont's sphero-hexagonal, sample 1B, 1897, for 5-inch rifle and 12-inch mortar.
Apr. 3	12	45	1,749	39,240	
	12	45	1,743	37,310	
Apr. 19	12	45	1,736	39,180	Du Pont's sphero-hexagonal, sample 1C, 1897, for 5-inch rifle and 12-inch mortar.

5-INCH B. L. RIFLE, STEEL, NO. 12.

Feb. 17	9	45	1,447	24,800	Du Pont's sphero-hexagonal, sample No. 15, for 5-inch siege rifle.
	10½	45	1,597	29,060	
	11½	45	1,702	34,267	
	12	45	1,736	36,620	Du Pont's sphero-hexagonal, sample No. 20, for 5-inch siege rifle.
	12	45	1,741	35,445	Du Pont's sphero-hexagonal, sample No. 19, for 5-inch siege rifle.
	11½	45	1,712	34,245	Du Pont's sphero-hexagonal, sample No. 18, for 5-inch siege rifle.
	12	45	1,756	36,820	
	11	45	1,653	29,710	Du Pont's sphero-hexagonal, sample No. 17, for 5-inch siege rifle.
	12	45	1,733	35,289	
	9	45	1,467	23,020	Du Pont's sphero-hexagonal, sample No. 16, for 5-inch siege rifle.
	11½	45	1,689	33,909	

5-INCH B. L. RIFLE, STEEL, NO. 16.

1896.					
Aug. 4	11½	45	1,660	31,582	Du Pont's sphero-hexagonal, sample No. 6, for siege guns and 12-inch mortars.
	11½	45	1,665	32,000	
	12½	45	1,731	34,580	
Aug. 13	12½	45	1,733	35,720	This round was fired with Du Pont sample of sphero-hexagonal powder for siege cannon which had been spread on floor of magazine for 72 hours in order to absorb moisture. It was fired to compare results with those of same powder fired as it came from manufacturer.

5-INCH B. L. RIFLE, STEEL, NO. 14.

Oct. 6	12	45	1,731	35,640	Du Pont's sphero-hexagonal, sample No. 11, for 5-inch B. L. rifle.
	13½	45	1,857	43,260	
	13½	45	1,805	35,200	Du Pont's sphero-hexagonal, sample No. 10, for 5-inch B. L. rifle.
	13½	45	1,797	36,156	
	13½	45	1,769	33,300	Du Pont's sphero-hexagonal, sample No. 12, for 5-inch B. L. rifle.
	13	45	1,788	36,289	Du Pont's sphero-hexagonal, sample No. 13, for 5-inch B. L. rifle.
	12	45	1,744	39,855	Du Pont's sphero-hexagonal, sample No. 14, for 5-inch B. L. rifle.

Brown prismatic powder—Continued.

5-INCH B. L. RIFLE, STEEL, No. 3.

Date.	Charge.	Projectile.	Velocity.	Pressure.	Remarks.
1896.	*Pounds.*	*Pounds.*	*Feet.*	*Pounds.*	
Aug. 3	9	45	1,469	24,140	Du Pont's sphero-hexagonal, sample No. 5, for siege cannon and 12-inch mortars.
	11¼	45	1,091	31,270	
Aug. 4	12½	45	1,772	37,710	
	12½	45	1,805	38.910	Du Pont's sphero-hexagonal, sample No. 8, for siege guns and 12-inch mortars.
	12	45	1,693	33,280	
	12½	45	1,735	35,070	
Aug. 13	12½	45	1,751	35,940	
Aug. 4	12½	45	1,766	38,200	Du Pont's sphero-hexagonal, sample No. 7, for siege guns and 12-inch mortars.
	12½	45	1,781	39,400	
Aug. 13	12½	45	1,790	39,540	
Aug. 4	12½	45	1,750	38,780	Du Pont's sphero-hexagonal, sample No. 9, for siege guns and 12-inch mortars.
	12½	45	1,771	37,940	
Aug. 13	12½	45	1,775	38,160	This round was fired with Du Pont sample of sphero-hexagonal powder for siege cannon which had been spread on the floor of the magazine for 72 hours in order to absorb moisture. It was fired to compare results with those of the same powder fired as it came from the manufacturer.

15-INCH RODMAN SMOOTHBORE M. L. GUN, No. 118.

Date.	Charge.	Projectile.	Velocity.	Pressure.	Remarks.
Sept. 11	90	454	1,377	14,589	Du Pont's sphero-hexagonal, sample No. 1, 1896, for 8-inch and 15-inch M. L. guns.
	120	453	1,561	20,730	
	138	453	1,695	26,200	
Dec. 21	117	452½	1,632	26,460	Du Pont's sphero-hexagonal, sample No. 1A, 1896, for 15-inch S. B. gun.
	117	455½	1,638	27,810	
1897.					
Jan. 5	125	454	1,693	29,330	Du Pont's sphero-hexagonal, sample 1A, 1897, for 15-inch S. B. gun.
	117	454	1,583	23,300	
	120	456½	1,659	27,913	Du Pont's sphero-hexagonal, sample No. 3, for 15-inch S. B. gun.
Feb. 4	110	458	1,533	21,479	
	124	455½	1,625	26,095	
Apr. 1	110	456	1,566	24,860	Du Pont's sphero-hexagonal, sample No. 4, for 15-inch S. B. gun.
	110	455	1,627	29,456	Du Pont's sphero-hexagonal, sample No. 5, for 15-inch S. B. gun.

Smokeless powders.

6-POUNDER DRIGGS-SCHROEDER R. F. GUN.

Date.	Charge.	Projectile.	Velocity.	Pressure.	Remarks.
1896.	*Ounces.*	*Pounds.*	*Feet.*	*Pounds.*	
Oct. 20	17	6	2,028	—32,000	Du Pont's smokeless, sample No. 1, received Oct. 9, 1896. The grains of this powder are flat square disks, about 0.35 inch on a side and 0.05 inch thick. They are graphited. The powder is translucent, and when held up to the light the color is a greenish yellow.
	17½	6	2,369	60,813	
	17½	6	2,082	28,480	
Oct. 24	18	6	2,124	31,327	
	19	6	2,184	33,300	
	19¼	6	2,218	34,067	
	19½	6	2,236	34,356	
	19½	6	2,277	35,444	
	19½	6	2,204	32,873	
Dec. 18	*15	6	1,620	15,670	Du Pont's smokeless: (*) No. 2, NN (11-5-30), and (†) No. 3, NN (11-5-25).
	†15	6	1,558	16,130	
	*19½	6	2,223	33,200	
	†19½	6	2,176	36,640	
	*20	6	2,309	36,220	
	†19	6	2,035	—32,000	
	†19½	6	2,115	32,000	
	†20½	6	2,238	40,065	
	†19½	6	2,124	33,360	
	*19¼	6	2,337	38,500	

Smokeless powders—Continued.

6-POUNDER DRIGGS-SCHROEDER R. F. GUN.

Date.	Charge.	Projectile.	Velocity.	Pressure.	Remarks.
1897.	*Ounces.*	*Pounds.*	*Feet.*	*Pounds.*	
Feb. 6	15	6	1,311	10,225	Du Pont's smokeless, No. 4. This powder is similar in form of grain to the French B. N. smokeless.
	17	6	1,377	−18,000	
	20	6	1,645	15,620	
	25	6	2,089	25,725	
Mar. 25	15	6	1,822	17,650	Du Pont's smokeless for 6-pounder, sample No. 5. The powder is 0.005 inch thick, about 1 inch wide, and in strips 7.4 inches in length. Color, light brown; enough flexibility to allow the strips to be bent double without breaking.
	18	6	2,140	26,260	
	20½	6	2,398	33,725	
	20¾	6	2,414	34,490	
	20¾	6	2,410	33,500	

3.2-INCH GERDOM.

Apr. 16	15⅛	16.5	1,540	32,480	Lot 1, 1897.	Du Pont's smokeless, lots 1, 2, 3, 4, 5, and 6. Lots 1 and 2 are alike, except that the grain of No. 1 is flat shaped and square, and that of No. 2 is in strips of about the length of the powder chamber; similar remarks apply to Nos. 3, 4, 5, and 6.
	14	16.5	1,416	27,060		
	14⅛	16.5	1,447	29,040		
	14¼	16.5	1,399	24,120	Lot 2, 1897.	
	14¾	16.5	1,465	27,380		
	14¼	16.5	1,365	25,910	Lot 3, 1897.	
	15	16.5	1,416	27,860		
	15¼	16.5	1,451	28,200		
	15⅛	16.5	1,500	32,220	Lot 4, 1897.	
	15¼	16.5	1,467	30,700		
	15	16.5	1,373	28,420	Lot 5, 1897.	
	15¾	16.5	1,434	32,740		
	16	16.5	1,387	25,200	Lot 6, 1897.	
	16⅛	16.5	1,407	25,480		
Apr. 23	16	16.5	1,550	34,180	Lot 1. 1897.	Uniformity test, Du Pont's smokeless. This powder is the same as that fired on Apr. 16, 1897.
	16	16.5	1,550	33,580		
	16	16.5	1,550	34,400		
	16	16.5	1,554	34,330		
	16	16.5	1,547	33,690		
	16⅛	16.5	1,593	35.560	Lot 2, 1897.	
	16⅛	16.5	1,606	36,640		
	16⅛	16.5	1,611	37,800		
	16⅛	16.5	1,590	33.540		
	16⅛	16.5	1,584	33,160		
	16¾	16.5	1,563	37,820	Lot 3, 1897.	
	16¾	16.5	1,550	36,780		
	16¾	16.5	1,542	36,880		
	16¾	16.5	1,537	34,860		
	16¾	16.5	1,545	36,090		
Apr. 24	16	16.5	1,528	32,840	Lot 4, 1897.	Uniformity test, Du Pont's smokeless. This powder is the same as that fired on Apr. 16, 1897.
	16¼	16.5	1,543	34,640		
	16¼	16.5	1,535	33,020		
	16¼	16.5	1,542	33,420		
	16¼	16.5	1.542	33,300		
	16¼	16.5	1,554	35,110		
	16¼	16.5	1,458	32,980	Lot 5, 1897.	
	16⅛	16.5	1,488	36,190		
	16⅛	16.5	1,459	31,890		
	16⅛	16.5	1,449	31,470		
	16⅛	16.5	1,481	36.640		
	16¼	16.5	1,463	28,000	Lot 6, 1897.	
	16¾	16.5	1,488	29.140		
	18⅛	16.5	1,552	32.700		
	18¾	16.5	1,540	30,620		
	18¾	16.5	1,558	32.400		

Smokeless powders—Continued.

3.2-INCH B. L. RIFLE, SEABURY R. F. GUN.

Date.	Charge.	Projectile.	Velocity.	Pressure.	Remarks.
1896.	*Ounces.*	*Pounds.*	*Feet.*	*Pounds.*	
July 7	16	16.5	1,434	26,760	Du Pont's smokeless, lot 1, 1896, composition "D." The powder is a square-shaped grain, the sides of the square about $\frac{1}{10}$ inch, the thickness about $\frac{1}{30}$ inch. The grain has a translucent appearance.
	$16\frac{1}{16}$	16.5	1,467	28,540	
	16	16.5	1,457	28,200	
	$15\frac{15}{16}$	16.5	1,446	27,655	
	$15\frac{15}{16}$	16.5	1,454	28,580	
	$15\frac{13}{16}$	16.5	1,447	27,580	
	$15\frac{3}{4}$	16.5	1,441	27,673	
	$15\frac{3}{4}$	16.5	1,441	27,800	
	$15\frac{3}{4}$	16.5	1,435	27,420	
	$15\frac{3}{4}$	16.5	1,456	28,400	
	$15\frac{3}{4}$	16.5	1,445	28,100	
July 13	$15\frac{3}{4}$	16.5	1,455	28,909	A cold-storage test of the same powder. The powder for this test was kept in a refrigerator for 2 days, then fixed cold and fired.
	$15\frac{3}{4}$	16.5	1,438	28,320	
	$15\frac{3}{4}$	16.5	1,435	27,691	
	$15\frac{3}{4}$	16.5	1,440	27,964	
	$15\frac{3}{4}$	16.5	1,447	28,500	
July 14	$15\frac{3}{4}$	16.5	1,427	26,360	A moisture test of the same powder. The powder was kept for 3 days in a closed vessel saturated with moisture from a dish of water contained in it, and then fired without drying.
	$15\frac{3}{4}$	16.5	1,434	27,927	
	$15\frac{3}{4}$	16.5	1,441	28,982	
	$15\frac{3}{4}$	16.5	1,444	28,660	
	$15\frac{3}{4}$	16.5	1,438	28,200	
July 15	$15\frac{3}{4}$	16.5	1,463	29,380	A wetting test of the same powder. This powder was dipped in water for 17 hours, then dried in the sun for 13 hours.
	$15\frac{3}{4}$	16.5	1,463	29,636	
	$15\frac{3}{4}$	16.5	1,462	30,060	
	$15\frac{3}{4}$	16.5	1,468	30,740	
July 17	$15\frac{3}{4}$	16.5	1,444	27,540	A heat test of the same powder. This powder was kept in a closed box for about 7 days, exposed to a temperature from 100° to 120° F. It was then allowed to cool for about 16 hours and then fired.
	$15\frac{3}{4}$	16.5	1,437	27,800	
	$15\frac{3}{4}$	16.5	1,465	28,891	A heat test of the same powder. This powder was put in cartridge cases exposed to a temperature of 100° to 120° F. for 7 days and then fired hot
	$15\frac{3}{4}$	16.5	1,461	28,660	
July 18	$15\frac{3}{4}$	16.5	1,401	25,320	A moisture test of the same powder. This powder was tested by exposing it in a closed box to air saturated with moisture from a dish of water. The time of exposure was 7 days, at the expiration of which the powder was fired.
	$15\frac{3}{4}$	16.5	1,417	26,320	

3.2-INCH B. L. RIFLE, DASHIELL R. F. GUN.

Date.	Charge.	Projectile.	Velocity.	Pressure.	Remarks.
1897.					
June 21	14	16.5	1,464	36,240	Test of smokeless powder, Du Pont's, lot 7, 1897. This powder is a square-shaped grain, 0.343 inch on a side and 0.033 inch thick. Its composition is not known. Color, amber yellow, and the grain is translucent. The powder was designed to give 35,000 pounds pressure in the 3.2-inch Gerdom R. F. field gun.
	$13\frac{3}{4}$	16.5	1,440	34,360	
	$13\frac{3}{4}$	16.5	1,416	29,750	
	$13\frac{3}{4}$	16.5	1,449	36,330	
	$21\frac{5}{8}$	16.5	1,488	27,600	Du Pont's smokeless, 2B, 1896; composition "C." To determine charge.
	$21\frac{5}{8}$	16.5	1,500	28,964	
	$21\frac{5}{8}$	16.5	1,493	29,500	
	$20\frac{3}{4}$	16.5	1,430	26,945	
	21	16.5	1,436	27,709	
July 10	$21\frac{1}{4}$	16.5	1,469	27,655	Du Pont's smokeless, 2B, 1896; composition "C." For ballistic uniformity.
	$21\frac{1}{4}$	16.5	1,460	27,836	
	$21\frac{1}{4}$	16.5	1,465	27,982	
	$21\frac{1}{4}$	16.5	1,458	27,764	
July 13	$20\frac{1}{8}$	16.5	1,379	25,240	Same as preceding. A cold-storage test of powder. The powder for this test was kept in a refrigerator for 2 days, then fixed cold and fired.
	$20\frac{1}{8}$	16.5	1,374	25,300	
	$20\frac{1}{8}$	16.5	1,376	24,600	
	$20\frac{1}{8}$	16.5	1,375	25,418	
July 14	$20\frac{1}{8}$	16.5	1,373	24,130	Same as preceding. A moisture test of powder. The powder for this test was kept for 3 days in a closed vessel, saturated with moisture from a dish of water contained in it, and then fired without drying.
	$20\frac{1}{8}$	16.5	1,367	24,740	
	$20\frac{1}{8}$	16.5	1,368	25,080	
	$20\frac{1}{8}$	16.5	1,355	24.130	
	$20\frac{1}{8}$	16.5	1,361	25,060	
July 15	$20\frac{1}{8}$	16.5	1,405	25,782	Same as preceding. A wetting test of powder. The powder was dipped in water, subsequently dried in the sun. The period of dipping was about 15 hours, and that of exposure to the sun 13 hours.
	$20\frac{1}{8}$	16.5	1,395	26,200	
	$20\frac{1}{8}$	16.5	1,399	26,520	
	$20\frac{1}{8}$	16.5	1,403	26,818	

Smokeless powders—Continued.

3.2-INCH B. L. RIFLE, DASHIELL R. F. GUN—Continued.

Date.	Charge.	Projectile.	Velocity.	Pressure.	Remarks.
1897.	*Ounces.*	*Pounds.*	*Feet.*	*Pounds.*	
July 17	20⅛	16.5	1,386	25,380	A heat test of same powder (Du Pont's smokeless, 2B, 1896, composition "C"). The powder was kept in a closed box for about 7 days, exposed to a temperature of from 100° to 120° F. It was then allowed to cool for about 16 hours, and then fixed and fired.
	20⅛	16.5	1,385	25,360	
	20⅛	16.5	1,418	25,764	A heat test of the same powder (composition "C"). This powder was put in cartridge cases and exposed to a temperature of 100° to 120° F. for 7 days, and then fired hot.
	20⅛	16.5	1,425	26,360	
July 18	20⅛	16.5	1,333	24,020	A moisture test of the same powder. This powder was tested by exposing it in a closed box to air saturated with moisture from a dish of water. The time of exposure was 7 days, at the expiration of which the powder was fired.
	20⅛	16.5	1,341	24,020	
July 25	20⅛	16.5	1,425	25,890	A heat test of the same powder. This powder was kept in a closed box at a temperature of about 100° to 120° F. for 15 days and then fired hot.
	20⅛	16.5	1,422	25,530	
July 24	20⅛	16.5	1,312	24,000	A moisture test of the same powder. The powder was placed in a closed box and in air saturated with moisture from a dish of water contained in the box. The time of exposure was 14 days, when the powder was taken out and fired without drying.
	20⅛	16.5	1,310	—24,000	

3.6 INCH B. L. MORTAR, STEEL, No. 3.

Date.	Charge.	Projectile.	Velocity.	Pressure.	Remarks.
1896. Aug. 11	4	20	343	5,000	Du Pont's smokeless for 3.6-inch mortar, sample No. 1, 1896. The powder is made in square-shaped grains. Each side of the square is about $\frac{1}{10}$ inch in length, and the thickness of the grain is about $\frac{1}{30}$ inch. The grain is extremely hard and breaks without bending. The color is cream. The samples are numbered in the inverse order of their quickness. Apparently, the thickness varies the same way; but the variation is slight. Partially burned grains showed some pitting. Burning grains projected from the gun at each fire, which diminished with the increase of the powder charge.
	8	20	600	13,150	
	9	20	660	14,530	
	9	20	662	15,300	
	9	20	655	14,290	
	9½	20	629	13,870	Du Pont's smokeless for 3.6-inch mortar, sample No. 2, 1896. Remark: Same as for sample 1.
	10½	20	681	16,180	
	10	20	670	15,980	
	10	20	668	15,680	
	10¾	20	630	13,690	Du Pont's smokeless for 3.6-inch mortar, sample No. 3. 1896. Remark: Same as for samples 1 and 2.
	11	20	638	14,130	
	11¼	20	653	14,870	
	11¼	20	655	14,690	
Sept. 24	8	20	805	21,111	Du Pont's smokeless for 3.6-inch mortar, sample No. 4, 1896. The grains of this powder are thin rectangular disks, about 0.34 by 0.37 inch and about 0.025 inch in thickness. After each round there is a small quantity of light gray smoke, which dissipates quickly.
	7	20	717	17,000	
	6½	20	671	14,533	
	6½	20	685	15,600	
	6½	20	675	14,378	
	7½	20	678	14,689	Du Pont's smokeless for 3.6-inch mortar, sample No. 5, 1896. The grains of this powder are thin rectangular disks, about 0.34 by 0.37 inch and about 0.03 inch in thickness. After each round there is a small quantity of light gray smoke, which dissipates quickly.
	7½	20	683	14,911	
	7½	20	678	15,075	
Oct. 19	5	20	588	12,025	Du Pont's .30-caliber rifle powder.
	5⅝	20	625	13,560	
	5⅞	20	671	16,560	
	5¾	20	651	15,100	

Smokeless powders—Continued.

3.6-INCH B. L. MORTAR, STEEL, NO. 3.

[Object of firing: A comparative test of smokeless powders for the determination of their suitability for adoption for use in the 7-inch and 3.6-inch mortars, and to obtain charge for specified velocity.]

Date.	Charge, in ounces and kind. .30-caliber rifle.	7-inch mortar, lot 1, 1896.	3.2-inch rifle, lot 1, 1896.	Projectile.	Velocity.	Pressure.	Remarks.
1897.				*Pounds.*	*Feet.*	*Pounds.*	
Jan. 30	$6\frac{1}{2}$	....	....	20	710	17,860	Du Pont's smokeless powders. After every round of the 7-inch and 3.2-inch powders, the ground in front of the muzzle was strewn with unburned grains, and some were found in the bore. There was considerably more of the 3.2-inch than of the 7-inch powder.
		9	....	20	757	19,220	
			9	20	618	12,225	
	$2\frac{1}{2}$	....	....	20	354	4,750	
		3	....	20	321	4,050	
			$3\frac{1}{2}$	20	314	3,875	
		$8\frac{5}{8}$	....	20	715	16,000	
			$10\frac{1}{2}$	20	744	17,650	
	$2\frac{5}{8}$	....	....	20	367	4,050	
		$3\frac{5}{8}$	....	20	354	3,875	
			$4\frac{1}{4}$	20	361	4,050	
			$3\frac{1}{2}$	20	309	3,700	

3.6-INCH B. L. MORTAR, STEEL, NO. 3.

Date.	Charge.	Projectile.	Velocity.	Pressure.	Remarks.
1897.	*Ounces.*	*Pounds.*	*Feet.*	*Pounds.*	
Feb. 1	$3\frac{7}{8}$	20	507	8,070	Du Pont's smokeless for .30-caliber rifle.
	$1\frac{7}{16}$	20	244	3,525	
	$2\frac{5}{8}$	20	363	4,575	
	$2\frac{5}{8}$	20	355	4,750	
	$2\frac{5}{8}$	20	362	4,925	
	$1\frac{11}{16}$	20	270	3,875	
	$1\frac{11}{16}$	20	285	3,875	
	$1\frac{11}{16}$	20	265	3,350	
	$3\frac{7}{8}$	20	493	7,730	
	$3\frac{7}{8}$	20	489	7,300	
	$6\frac{1}{8}$	20	715	17,650	
	$6\frac{1}{8}$	20	708	17,110	
	$6\frac{1}{8}$	20	713	17,700	
Feb. 18	$5\frac{11}{16}$	20	673	15,150	
	$1\frac{3}{4}$	20	271	3,700	
	$1\frac{3}{4}$	20	277	3,700	
	$1\frac{3}{4}$	20	276	3,875	
	$5\frac{9}{16}$	20	637	13,560	
	$5\frac{10}{16}$	20	657	15,125	
	$5\frac{10}{16}$	20	639	13,440	
	$3\frac{7}{8}$	20	487	8,970	
	$3\frac{7}{8}$	20	476	7,800	
	$5\frac{11}{16}$	20	664	15,450	
Apr. 22	$5\frac{11}{16}$	20	680	16,180	
	$5\frac{11}{16}$	20	655	15,025	
	$5\frac{11}{16}$	20	657	14,711	
	6	20	687	16,360	

7-INCH B. L. MORTAR, STEEL, No. 1.

Date.	Charge.	Projectile.	Velocity.	Pressure.	Remarks.
1896.	*Lbs. Oz.*	*Pounds.*	*Feet.*	*Pounds.*	Du Pont's smokeless for 7-inch mortar, sample No. 1. This powder is made into square-shaped grains. Each side of the square is about $\frac{1}{10}$ inch in length. The thickness of the grain varies from about $\frac{1}{32}$ inch for No. 1 sample to $\frac{1}{16}$ inch for No. 3 sample. The grain is extremely hard, and breaks without bending. The color is cream. The samples are numbered in the inverse order of their quickness. Partially burned grains found in the bore showed some pitting. Burning grains were projected from the gun at each fire, but the number were small with the increase of the powder charge.
Aug. 12	4 0	125	897	24,800	
	3 8	125	802	19,290	
	3 2	125	721	14,980	
	3 2	125	726	15,200	

Smokeless powders—Continued.

7-INCH B. L. MORTAR, STEEL, NO. 1.

Date.	Charge.	Projectile.	Velocity.	Pressure.	Remarks.
1896.	*Lbs. Oz.*	*Pounds.*	*Feet.*	*Pounds.*	
Aug. 12	3 2	125	676	13,350	Du Pont's smokeless for 7-inch mortar, sample No. 2.
	3 3	125	681	14,240	
	3 4	125	696	14,310	
	3 4	125	695	14,000	
Aug. 13	3 8	125	710	16,580	Du Pont's smokeless for 7-inch mortar, sample No. 3.
	3 8	125	727	16,720	
	3 8	125	729	16,940	
Sept. 22	3 2	125	825	19,760	Du Pont's smokeless for 7-inch mortar, sample No. 6, 1896. The grains of this powder are thin rectangular disks about 0.34 by 0.37 inch and about 0.03 inch in thickness. Color, dark cream.
	2 15	125	793	18,036	
	2 14½	125	793	17,825	
	2 4	125	746	17,575	Du Pont's smokeless for 7-inch mortar, sample No. 4, 1896. The grains of this powder are thin rectangular disks about 0.34 by 0.37 inch, and about 0.03 inch in thickness. Color, dark cream.
	2 4	125	750	18,418	
	2 4	125	755	18,291	
	2 12	125	806	19,133	Du Pont's smokeless for 7-inch mortar, sample No. 5, 1896. Remark: Same as preceding.
	2 10½	125	790	18,509	
	2 10½	125	782	18,400	
Oct. 17	1 4	125	557	9,371	Du Pont's smokeless for .30-caliber rifle. This powder is graphited. The grains are very small solid cylinders intended for the .30-caliber rifle. Is of the Peyton composition.
	1 13	125	716	19,980	

7-INCH B. L. MORTAR, STEEL, NO. 1.

[Object of firing: A comparative test of smokeless powders for the determination of their suitability of adoption for use in the 3.6-inch and 7-inch mortars.]

Date.	Charges, in ounces and kind.			Projectile.	Velocity.	Pressure.	Remarks.
	.30-caliber rifle.	3.2-inch rifle, lot 1, 1896.	7-inch mortar, lot 1, 1896.				
1896.				*Pounds.*	*Feet.*	*Pounds.*	
Jan. 15	12	....	....	125	403	4,230	Du Pont's smokless for .30 caliber rifle, 3.2-inch rifle, and 7-inch mortar.
	....	....	32	125	671	11,400	
	....	20	....	125	409	4,230	
	10	....	....	125	339	3,850	
	....	....	20	125	482	6,080	
	....	16	....	125	342	3,530	
	9½	....	....	125	321	3,350	
	....	....	14	125	369	3,350	
	....	15½	....	125	342	3,350	
	....	....	12	125	337	3,530	
	13½	....	....	125	606	4,050	
	....	14½	....	125	322	3,350	
	....	....	11⅛	125	336	3,350	
	....	....	17⅝	125	424	3,875	
	12½	....	....	125	396	3,700	
	....	21½	....	125	421	4,050	
Jan. 16	12½	....	....	125	401	3,875	
	25	....	....	125	648	13,533	
	12¾	....	....	125	398	4,400	
	28	....	....	125	705	16,980	
	13	....	....	125	410	5,705	
Jan. 22	13	....	....	125	402	4,750	
	13	....	....	125	394	4,750	
	13	....	....	125	409	5,275	
	....	....	17¾	125	426	3,875	
	....	....	17¾	125	431	4,400	
	....	....	17¾	125	434	5,100	
	....	....	17¾	125	431	5,450	
	....	16	....	125	347	4,050	
	....	22½	....	125	450	4,750	
	....	....	22½	125	437	4,400	
	....	....	22½	125	438	4,925	
	....	....	22½	125	449	5,100	

Smokeless powders—Continued.

10-INCH B. L. RIFLE, STEEL, NO. 51.

Date.	Charge.	Projectile.	Velocity.	Pressure.	Remarks.
1897.	*Pounds.*	*Pounds.*	*Feet.*	*Pounds.*	
May —	110	576½	1,793	24,000	Du Pont's smokeless, sample No. 1, 1897. This powder is in strips, 2 feet 5¼ inches long; width, 1.7 inches; thickness, varying from 0.217 inch to 0.245 inch. Color, light brown. May be bent double without breaking. Produces considerable smoke, which dissipates rapidly.
	130	576	2,135	32,770	

12-INCH B. L. MORTAR, STEEL, TYPE.

Date.	Charge.	Projectile.	Velocity.	Pressure.	Remarks.
Mar. 24	30½	800	1,073	30,570	Du Pont's smokeless, sample No. 2, 1897, for 12-inch B. L. mortars. The strips of this powder are 18 inches in length, 0.667 inch in width, and 0.0585 inch in thickness, and when held up to the light are the color of amber.
	25	800	952	24,580	Du Pont's smokeless, sample No. 1, 1897, for 12-inch mortar. The strips of this powder are 17 inches in length, 0.6 inch in width, and 0.49 inch in thickness, and when held up to the light are color of amber.
	27½	800	1,020	30,078	

12-INCH B. L. MORTAR, STEEL, NO. 5.

Date.	Charge.	Projectile.	Velocity.	Pressure.	Remarks.
May 3	33	800	1,107	30,418	Du Pont's smokeless, lot 2, 1897, for 12-inch mortar. The grains of this are in strips, 6.5 inches long, 0.675 inch wide, and $\frac{1}{16}$ inch thick and dark brown color.
	36½	800	1,107	30,418	
	37	800	1,185	35,265	
	37	800	1,187	35,967	
Apr. 9	33	800	1,098	28,667	
June 21	45	800	1,149	28,200	Du Pont's smokeless, sample No. 3, 1897, for 12-inch mortars. This powder is in strips, 19.75 inches long, $1\frac{7}{16}$ inches wide, 0.15 inch thick, and dark brown in color. Produces considerable smoke at discharge, which dissipates rapidly.
June 7	33	800	1,101	29,010	Du Pont's smokeless, lot 1, 1897, for 12-inch mortars. This powder is seal-brown color; is semitranslucent and is evidently rolled into sheets about 0.07 inch in thickness which are cut into grains 0.7 of an inch. There is considerable smoke or vapor at the discharge, and a slight oily residue is left in the piece.
	35	800	1,151	33,311	
	35	800	1,148	33,360	
	35	800	1,148	33,516	
	35	800	1,140	33,470	

Very respectfully, your obedient servant,

FRANK HEATH,
Captain, Ordnance Department, U. S. A., Commanding.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

(23228—Enc. 1)

APPENDIX 22.

CONE OF DISPERSION OF SHRAPNEL.

(19 plates.)

SANDY HOOK PROVING GROUND,
September 21, 1897.

SIR: I have the honor to forward herewith records of firings made in compliance with your instructions of July 27 (no number) and of July 31, No. 15813, for the purpose of obtaining data for determining the cone dispersion of service shrapnel for 3.2-inch rifle. Fifty-four rounds in all were fired, giving targets as follows:

Series 1. Five targets with 13½-pound shrapnel, band five-eighths inch from base; initial velocity, 1,685 feet per second; burst by wood screen placed 90 feet in front of target.

Series 2. Five targets with 16½-pound shrapnel, band 1.75 inches from base; initial velocity, 1,450 feet per second; burst by wood screen placed 90 feet in front of target.

Series 3. Five targets with 16½-pound shrapnel, band five-eighths inch from base; initial velocity, 1,450 feet per second; burst at wood screen placed 90 feet from target.

Series 4. Four targets with 13½-pound shrapnel, band five-eighths inch from base; burst by standard point combination fuse, as nearly as possible to 90 feet in front of the target.

The above plotted targets are forwarded herewith.

With the combination fuses uniform positions of the point of burst could not be obtained. When cut to two seconds the positions varied 115 feet, and when cut to one and five-sixths seconds the variation was 145 feet. The firings were continued until the supply of fuses was exhausted, and with 15 rounds 4 targets were obtained.

The results in rounds 1025 and 1034 are abnormal. No explanation can be suggested, except that there may have been a variation in the quality of the material used in the manufacture of these particular shrapnel. This is evidently the case in round 1034, where the number of small fragments, as indicated by the number imbedded, is excessive.

Very respectfully, your obedient servant,

FRANK HEATH,
Captain, Ordnance Department, U. S. A.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

(15813—Encs. 158 and 159)

NOTE APPENDED IN ORDNANCE OFFICE.

Both patterns of the 3.2-inch shrapnel used in these tests contained the bursting charge in the head, and have been previously described in these reports. (See Appendix 46, Report of 1892, Pl. I, for the 13.5-pound, and Appendix 7, Report of 1896, Pl. I, for the 16.5-pound shrapnel.) The 13.5-pound shrapnel contains 162 hardened lead balls, about 170 grains each, or 41 to the pound, and 38 pieces of separators, etc., making a total of 200 pieces. The 16.5-pound shrapnel contains 192 balls, weighing about 42 to the pound, and 44 separators, etc., making a total of 236 pieces. When the shrapnel is burst some of the pieces are broken and the number of fragments increased. The 16.5-pound shrapnel, with band 0.625 inch from base, were prepared by placing new bands in this position, and by turning down the projecting portion of the band left in the position 1.75 inches from base, where it was placed when the shrapnel were manufactured. In view of the construction of the shrapnel (see drawing), the effect of thus reducing the strength of the original band should be to reduce the resistance of the shrapnel case to the bursting effort of its powder charge and tend to increase the dispersion. The combination time and percussion fuse used in the fourth series of firings is the Frankford Arsenal 15-seconds fuse, model 1894, with lead-drawn time train graduated for cutting at one-sixth second intervals. The point percussion fuse used in the three remaining series is a simple fuse, consisting essentially of a percussion cap placed in the point, to be exploded on impact with the wood screen, with a powder-charged channel that communicates the explosion of the cap to the powder charge in the shrapnel.

The object of the firings was primarily to determine the cone of dispersion for the shrapnel. Also, by comparison of series 1 and 4, to ascertain the difference in dispersion for 13.5-pound shrapnel fired through a 1-inch pine wood screen to cause burst, and fired with the combination time and percussion fuse to burst freely in air, and by comparison of series 2 and 3 to ascertain the difference in dispersion for 16.5-pound shrapnel, with band, in the two positions stated.

The cone of dispersion for each round shown on the targets herewith has been deduced by plotting on the recorded target a circle to include the group of hits, excepting a few scattered hits, which are neglected. This is taken as the intersection of the cone of dispersion with the target, and the angle of the cone then computed from the known position of its apex or the distance of the point of burst of shrapnel in front of target, the trajectories of the balls, etc., being considered as straight lines. A source of error in this method lies in the selection of the circle taken to measure the cone of dispersion on the target. Those taken in the present case are derived from the judgment of several persons who agreed nearly in their estimates.

The following table contains the angle of the cone of dispersion for each round and other data from the firings:

Shrapnel.	Round No.	Distance of burst in front of target.	Number of hits on target.	Diameter of circle of dispersion on target.	Angle of cone of dispersion.		Remarks.
		Feet.		*Feet.*	°	′	
Series 1. 13.5-pound shrapnel.	1004	85	296	25	16	44	Fired with point percussion fuse to burst on passing through wood screen, 1-inch pine, 90 feet in front of target. Computed angle, 19° 40′
	1007	75	193	23	17	26	
	1009	85	301	28	18	42	
	1011	*a* 90	307	28	17	42	
	1013	70	304	26.5	21	26	
Mean	....	81	280	26.1	18	24	
Series 2. 16.5-pound shrapnel, band 1.75 inches from base.	1016	78	296	22	16	04	Fired through wood screen, as in series 1. Computed angle, 17° 58′.
	1017	80	280	23	16	42	
	1018	85	290	25	16	44	
	1019	80	301	23.5	16	22	
	1020	85	207	24	16	26	
Mean	....	81.2	275	23.5	16	28	
Series 3. 16.5-pound shrapnel, band 0.625 inch from base.	1021	85	300	22	14	44	Fired through wood screen, as in series 1 and 2. Computed angle, 17° 58′.
	1022	80	351	24	17	04	
	1023	80	331	26	18	30	
	1024	85	308	24	16	04	
	1025	80	176	23	16	22	
Mean	....	....	293	23.8	16	44	
Series 4. 13.5-pound shrapnel.	1027	55	273	16	16	34	Fired with point combination time and percussion fuse and burst freely in air by time cutting. Computed angle, 19° 40′.
	1032	100	294	27	15	22	
	1033	80	298	21	14	58	
	1034	90	430	24	15	02	
Mean	....	81.25	324	22	15	29	

a Struck one of the supports of the wood screen and burst at screen.

A comparison of the angles of the 16.5-pound shrapnel (series 2 and 3) with band in two positions shows that the position of band produced no material effect upon the dispersion. The slightly greater dispersion for the altered shrapnel (band 0.625 inch from base) may be attributed to the reduction in the resistance of the case to bursting already alluded to.

The difference of dispersion for the 13.5-pound shrapnel, series 1, burst by firing through the wood screen, and series 2, burst freely in air by time fuse, amounts to nearly 3°. The greater dispersion and variation in angle of cone in the screen series indicate a loss of terminal velocity and other disturbing causes, due to penetrating the screen, which render the results less reliable than those derived from the time series. The variations in the angle of cone for the 16.5-pound shrapnel are not so great as the 13.5 in the screen firings, which might be expected by reason of their greater weight and sectional density.

The computed angles given under "remarks" in the table are the angles for the cone of dispersion derived from the commonly applied formula—

$$\tan \tfrac{1}{2}\,\alpha = \frac{(V_l)}{v} \;\ldots\ldots\ldots\ldots (1),$$

wherein α represents the angle of the cone of disperson, V_l the lateral velocity (supposed constant) $= V_0 \tan i$, wherein V_0 represents the muzzle velocity and i the angle of twist of rifling at muzzle, v the remaining velocity of shrapnel at point of burst. The application of this formula will evidently give values of α increasing with the range.

The angle of cone of dispersion for the 13.5-pound shrapnel, for the average range of burst, 975 yards (v=1,222 feet per second), computed by this formula, is 19° 40′ or 4° 11′ greater than the angle determined under the best conditions of experiment. To make the formula produce the experimental value requires the introduction of an empirical factor, and for this particular case it would become—

$$\tan \tfrac{1}{2}\,\alpha = 0.785\,\frac{(V_{,})}{v}.$$

This factor can be verified only by firings at different ranges; its value for general application could then no doubt be expressed as a function of the range or remaining velocity.

The formula applicable to a shrapnel with bursting charge in the head, like the present, as given in the Revue d'Artillerie, October, 1896, page 68, is of the form—

$$\tan \tfrac{1}{2}\,\alpha = \frac{(V_{,})}{v-v'} \ldots\ldots\ldots\ldots (2),$$

wherein v-v′ represents the velocity of balls at the point of burst or the remaining velocity of the projectile diminished by the velocity due to the bursting charge. But since the computed angles of dispersion from Eq. (1) are already greater than the experimental, it is seen that Eq. (2) is incompatible with the results of the present experiments. Since to produce the experimental angle from Eq. (2) would require v′ to be positive, which is directly contrary to the hypothesis on which it is based, namely, that the effect of the head charge is to produce a retardation in velocity of balls from that of the remaining velocity of projectile at the point of burst.

As regards the action of the fuses, the following may be noted:

In the firings through a 1-inch pine board screen, with the point percussion fuse, the shrapnel burst at an average distance of about 9 feet from the screen—minimum 5 feet and maximum 20 feet.

With the combination fuse the effort to get a complete group of hits from a single shrapnel on a vertical target at a range of 1,000 yards was successful in only 4 out of 15 rounds fired. The very creditable performance of the fuse is shown, however, by the records of 9 rounds fired with the same cutting of fuse, one and five-sixths seconds. In these the average range to point of burst was 949 yards, the greatest variation from this mean was 24 yards, and the extreme variation for individual shots 48 yards, corresponding to a time interval of about 0.11 of a second.

Record of firing with 3.2-inch B. L. rifle (steel), No. 32, Watervliet Arsenal,

[Object of firing, to determine the cone of

Date.	No. of fire.	Powder. Kind.	Powder. Weight.	Projectile. Kind.	Projectile. Weight.	Instrumental velocity, 125 feet from muzzle.	Pressure, pounds per square inch of bore.	Recoil.	Wind, strength and direction.
1897.			*Lbs. Oz.*		*Lbs. Oz.*	*Feet.*		*Feet.*	
Aug. 3	987	Du Pont's sphero-hexagonal, U.F., lot 3.	3 8	Shell cast iron, rebanded; band 0.625 inch from base.	13 8	1,595 1,595 1,595	50, 34,070	10	Wind from front, 8 miles an hour; barometer, 30.20; thermometer, 82°; humidity, 72.
Aug. 3	988		3 9		13 8	1,637 1,638 1,639	60, 34,420	11	
Aug. 3	989		3 10		13 8	1,655 1,657 1,659	50, 34,040	12	
Aug. 3	990		3 10		13 8	1,673 1,673 1,673	60, 35,180	11	
Aug. 3	991		3 10		13 8	1,663 1,663 1,663	50, 34,380	12	
Aug. 3	992		3 6	Shell cast iron, rebanded; band 1.75 inches from base.	16 8	1,493 1,490 1,487	60, 34,380	11	
Aug. 3	993		3 4½		16 8	1,468 1,470 1,471	50, 34,000	10	
Aug. 3	994		3 3½		16 8	1,435 1,436 1,437	60, 32,910	12	
Aug. 4	995	Du Pont's sphero-hexagonal, U.F., lot 20.	3 4	Shell cast iron, rebanded; band 0.625 inch from base.	16 8	1,435 1,436 1,436	50, 31,800	12	Wind calm; barometer, 30.25; thermometer, 85°; humidity, 56.
Aug. 4	996		3 4		16 8	1,437 1,439 1,440	60, 30,000	12	
Aug. 4	997		3 4		16 8	1,450 1,450 1,450	50, 31,700	12	
						50+15/7			

at Sandy Hook Proving Ground, from August 3 to August 4, 1897.

dispersion of Frankford Arsenal shrapnel.]

Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
....	
....	
....	
....	
....	
....	Gun mounted on Buffington steel field carriage, No. 18, bow-spring brakes. Cannon friction primers, model 1897, F. A., September, 1890. Fired into field butt No. 2. 32,000 coppers of 1895.
....	
....	
....	
....	
The upper bow of left bow-spring brake broken near the shoe.	

Record of firing with 3.2-inch B. L. rifle (steel), No. 32, Watervliet Arsenal,

Date.	No. of fire.	Powder. Kind.	Powder. Weight.	Projectile. Kind.	Projectile. Weight.	Elevation.	Wind, strength and direction.
1897.			*Lbs. Oz.*		*Lbs. Oz.*	° ′	
Aug. 9	998	Du Pont's sphero-hexagonal, U. F., lot 3.	3 10	Shell, ⅝-inch band.	13 8	0 45	Wind from rear, 14 miles an hour; barometer, 30.12; thermometer, 70°; humidity, 67.
Aug. 9	999		3 10		13 8	0 38	
Aug. 9	1000		3 10	Shrapnel, ⅝-inch band.	13 8	0 38	
Aug. 9	1001		3 10		13 8	0 38	
Aug. 11	1002		3 10	Shell, ⅝-inch band.	13 8	0 38	Wind from right and rear, 14 miles an hour; barometer, 29.79; thermometer, 71°; humidity, 71.
Aug. 11	1003		3 10		13 8	0 38	
Aug. 11	1004		3 10	Shrapnel, ⅝-inch band.	13 4 4 powder, bursting charge. 13 8	0 38	
Aug. 11	1005		3 10		13 4 4 powder, bursting charge. 13 8	0 38	
Aug. 11	1006		3 10	Shell, ⅝-inch band.	13 8	0 38	
Aug. 11	1007		3 10	Shrapnel, ⅝-inch band.	13 4½ 3½ powder, bursting charge. 13 8	0 38	
Aug. 16	1008		3 10	Shell, ⅝-inch band.	13 8	....	Wind from right, 8 miles an hour; barometer, 29.95; thermometer, 85°; humidity, 70.
Aug. 16	1009		3 10	Shrapnel, ⅝-inch band.	13 4½ 3½ powder, bursting charge. 13 8	0 36	
Aug. 16	1010		3 10	Shell, ⅝-inch band.	13 8	....	
Aug. 16	1011		3 10	Shrapnel, ⅝-inch band.	13 4 4 powder, bursting charge. 13 8	0 36	

at Sandy Hook Proving Ground, from August 9 to August 26, 1897.

Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Sighting shot.	
....do.	
Missed screen; burst on passing through target.	
....do.	
Sighting shot.	
....do.	
Struck the screen 1½ feet right and 1½ feet below center, passed through, and burst 85 feet in front of the target. Following hits on target: Bullets through ... 150 Fragments through ... 114 Fragments embedded ... 27 Fragments made mark ... 5 Total ... 296	Rounds 998 to 1,001 were fired at a screen 13 feet wide by 11½ feet high, 10 feet above the ground. The shrapnel was fired to burst on passing through a 1-inch screen, 26 feet wide and 16 feet high, raised 10 feet above the ground, 90 feet in front of target. Target 1,000 yards from gun, 39 feet wide by 28 feet high and 1 inch thick, covered with building paper. Deflection was taken at 1½ to 2½ points right, depending on the wind and the part of the target desired to be hit.
Struck the screen 5 feet below and 1 foot left of center, and burst after passing through. The location of burst could not be determined and target thrown out.	
Sighting shot.	
Struck the screen 2 feet above and 1½ feet left of center, passed through, and burst 75 feet in front of target. Following hits on target: Bullets through ... 130 Fragments through ... 61 Fragments embedded ... 2 Fragments made mark ... 0 Total ... 193	
Sighting shot.	
Struck the center of screen, passed through, and burst 85 feet in front of target. Following hits on target: Bullets through ... 159 Fragments through ... 92 Fragments embedded ... 40 Fragments made mark ... 10 Total ... 301	
Sighting shot.	
Struck the screen 1 foot above and 1 foot right of center, passed through, and burst 90 feet in front of target. It cut the 3 by 4 inch upright in two. Following hits on target: Bullets through ... 154 Fragments through ... 99 Fragments embedded ... 48 Fragments made mark ... 6 Total ... 307	

Record of firing with 3.2-inch B. L. rifle (steel), No. 32, Waterrliet Arsenal,

Date.	No. of fire.	Powder. Kind.	Powder. Weight. Lbs.	Powder. Weight. Oz.	Projectile. Kind.	Projectile. Weight. Lbs.	Projectile. Weight. Oz.	Elevation. °	Elevation. ′	Wind, strength and direction.
1897. Aug. 17	1012	Du Pont's sphero-hexagonal, U. F., lot 3.	3	10	Shell, ⅝-inch band.	13	8	0	36	Wind from rear, 19 miles an hour; barometer, 30.14; thermometer, 74°; humidity, 82.
Aug. 17	1013	Du Pont's sphero-hexagonal, U. F., lot 3.	3	10	Shrapnel, ⅝-inch band.	13 13	4½ 3½ powder, bursting charge. 8	0	36	Wind from rear, 19 miles an hour; barometer, 30.14; thermometer, 74°; humidity, 82.
Aug. 19	1014	Du Pont's sphero-hexagonal, U. F., lot 3.	3	3½	Shell, 1.75-inch band.	16	8	0	5	Wind from rear, 10 miles an hour; barometer, 30.19; thermometer, 74°; humidity, 82.
Aug. 19	1015	Du Pont's sphero-hexagonal, U. F., lot 3.	3	3½	Shell, 1.75-inch band.	16	8	0	55	Wind from rear, 10 miles an hour; barometer, 30.19; thermometer, 74°; humidity, 82.
Aug. 19	1016	Du Pont's sphero-hexagonal, U. F., lot 3.	3	3½	Shrapnel, band 1.75 inches from base.	16 16	4 4 powder, bursting charge. 8	0	55	Wind from rear, 10 miles an hour; barometer, 30.19; thermometer, 74°; humidity, 82.
Aug. 19	1017	Du Pont's sphero-hexagonal, U. F., lot 3.	3	3½	Shrapnel, band 1.75 inches from base.	16 16	4 4 powder, bursting charge. 8	0	55	Wind from rear, 10 miles an hour; barometer, 30.19; thermometer, 74°; humidity, 82.
Aug. 19	1018	Du Pont's sphero-hexagonal, U. F., lot 3.	3	3½	Shrapnel, band 1.75 inches from base.	16 16	4 4 powder, bursting charge. 8	0	00	Wind from rear, 10 miles an hour; barometer, 30.19; thermometer, 74°; humidity, 82.
Aug. 23	1019	Du Pont's sphero-hexagonal, U. F., lot 3.	3	3½	Shrapnel, band 1.75 inches from base.	16 16	4 4 powder, bursting charge. 8	0	00	Wind from front, 14 miles an hour; barometer, 30.13; thermometer, 69°; humidity, 90.
Aug. 23	1020	Du Pont's sphero-hexagonal, U. F., lot 20.	3	3½	Shrapnel, band 1.75 inches from base.	16 16	4 4 powder, bursting charge. 8	0	00	Wind from front, 14 miles an hour; barometer, 30.13; thermometer, 69°; humidity, 90.
Aug. 23	1021	Du Pont's sphero-hexagonal, U. F., lot 20.	3	4	Shrapnel, band ⅝ inch from base.	16 16	4 4 powder, bursting charge. 8	0	55	Wind from front, 14 miles an hour; barometer, 30.13; thermometer, 69°; humidity, 90.

at Sandy Hook Proving Ground, from August 9 to August 26, 1897—**Continued.**

Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Sighting shot	
Struck the screen 1½ feet right of center, passed through, and burst 70 feet in front of target. Following hits on target: Bullets through ... 142 Fragments through ... 91 Fragments embedded ... 66 Fragments made mark ... 5 Total ... 304	
Sighting shot	
....do	
Struck the screen 1½ feet below and 1 foot right of center, passed through, and burst 78 feet in front of target. Following hits on target: Bullets through ... 185 Fragments through ... 75 Fragments embedded ... 36 Total ... 296	
Struck the screen 2 feet below and 6½ feet right of center, passed through, and burst 80 feet in front of target. The following hits on target: Bullets through ... 177 Fragments through ... 62 Fragments embedded ... 41 Total ... 280	
Struck the screen 1 foot below and 1½ feet left of center, passed through, and burst 85 feet in front of target. The following hits on target: Bullets through ... 176 Fragments through ... 79 Fragments embedded ... 35 Total ... 290	
Struck the screen 2½ feet right of center, passed through, and burst 80 feet in front of target. The following hits on target: Bullets through ... 184 Fragments through ... 74 Fragments embedded ... 43 Total ... 301	
Struck the screen 1½ feet below and 1½ feet right of center, passed through, and burst 85 feet in front of target. The following hits on target: Bullets through ... 179 Fragments through ... 58 Fragments embedded ... 50 Total ... 287	
Struck the screen 1½ feet below and 1½ feet left of center, passed through and burst 85 feet in front of target. The following hits on target: Bullets through ... 171 Fragments through ... 69 Fragments embedded ... 58 Fragments made mark ... 2 Total ... 300	

Record of firing with 3.2-inch B. L. rifle (steel), No. 32, Watervliet Arsenal,

Date.	No. of fire.	Powder. Kind.	Powder. Weight.	Projectile. Kind.	Projectile. Weight.	Elevation.	Wind, strength and direction.
1897.			*Lbs. Oz.*		*Lbs. Oz.*	° ′	
Aug. 25	1022	Du Pont's sphero-hexagonal, U. F., lot 20.	3 4	Shrapnel, band ⅝ inch from base.	16 4 4 powder, bursting charge. 16 8	0 55	Wind from rear, 13 miles an hour; barometer, 30; thermometer, 81°; humidity, 72.
Aug. 25	1023		3 4		16 4 4 powder, bursting charge. 16 8	0 55	
Aug. 26	1024		3 4		16 4 4 powder, bursting charge. 16 8	0 55	Wind from rear, 9 miles an hour; barometer, 30.10; thermometer, 82°; humidity, 66.
Aug. 26	1025		3 4		16 4 4 powder, bursting charge. 16 8	0 55	

Record of firing with 3.2-inch B. L. rifle (steel), No. 32, Watervliet Arsenal,

Date.	Number of fire.	Powder. Kind.	Powder. Weight.	Fuse cut to seconds.	Projectile. Kind.	Projectile. Weight.	Elevation.	Wind, strength and direction.
1897.			*Lbs. Oz.*			*Lbs. Oz.*	° ′	
Aug. 30	1026	Du Pont's sphero-hexagonal. U. F., lot 3.	3 10	$2\frac{1}{4}$	Shrapnel, band ⅝ inch from base.	13 $4\frac{1}{2}$ $3\frac{1}{2}$ bursting charge of rifle powder. 13 8	0 36	Wind from rear, 12 miles an hour; barometer, 30.08; thermometer, 82°; humidity, 69.
Aug. 30	1027		3 10	2		13 $4\frac{1}{2}$ $3\frac{1}{2}$ bursting charge of rifle powder. 13 8	0 36	
Aug. 30	1028		3 10	2		13 4 4 bursting charge of rifle powder. 13 8	0 36	
Aug. 30	1029		3 10	2		13 $4\frac{1}{2}$ $3\frac{1}{2}$ bursting charge of rifle powder. 13 8	0 36	
Aug. 30	1030		3 10	$1\frac{3}{8}$		13 4 4 bursting charge of rifle powder. 13 8	0 36	

at Sandy Hook Proving Ground, from August 9 to August 26, 1897—**Continued.**

Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Struck the screen 2½ feet above and 2 feet left of center, passed through and burst 80 feet in front of the target. The following hits on target: Bullets through .... 181 Fragments through .... 95 Fragments embedded .... 75 Total 351	
Struck the screen 1½ feet above and 1½ feet right of center, passed through and burst 80 feet in front of target. The following hits on target: Bullets through .... 182 Fragments through .... 94 Fragments embedded .... 55 Total 331	
Struck the screen 1½ feet below and 1½ feet left of center, passed through and burst 85 feet in front of target. The following hits on target: Bullets through .... 174 Fragments through .... 84 Fragments embedded .... 50 Total 308	
Struck the screen 1 foot below and 3 feet right of center, passed through and burst 80 feet in front of target. The following hits on target: Bullets through .... 98 Fragments through .... 46 Fragments embedded .... 32 Fragments made mark .... 0 Total 176	

at Sandy Hook Proving Ground, from August 30 to September 2, 1897.

Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Was not fired directly at the target. Burst 100 feet beyond.	
Burst 55 feet short of target. Following hits on target: Bullets through .... 138 Fragments through .... 90 Fragments embedded .... 44 Total 272	
Burst after passing through target, due probably to the action of the percussion feature.	This firing was with F. A. shrapnel, using the F. A. 15-second point combination time fuse.
Burst 60 feet beyond target.	
Burst 100 feet short of target, and too high to make a satisfactory target record.	

Record of firing with 3.2-inch B. L. rifle (steel), No. 32, Watervliet Arsenal, at

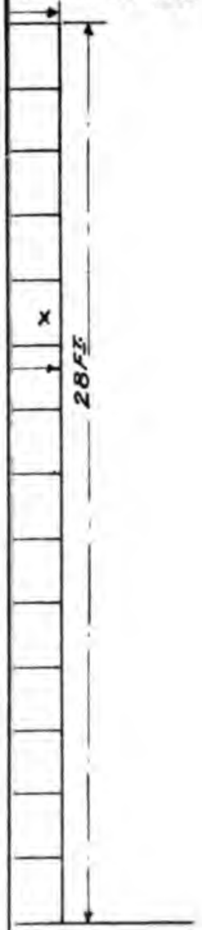
Date.	Number of fire.	Powder. Kind.	Powder. Weight.	Fuse cut to seconds.	Projectile. Kind.	Projectile. Weight.	Elevation.	Wind, strength and direction.
1897.			*Lbs. Oz.*			*Lbs. Oz.*	° ′	
Aug. 31	1031	Du Pont's sphero-hexagonal, U. F., lot 20.	3 10	2	Shrapnel, band ⅝ inch from base.	13 4; 4 bursting charge of rifle powder.; 13 8	0 36	Wind from right and rear, 6 miles an hour; barometer, 30.18; thermometer, 83°; humidity, 70.
Aug. 31	1032		3 10	1⅝		13 4; 4 bursting charge of rifle powder.; 13 8	0 36	
Aug. 31	1033		3 10	1⅝		13 4; 4 bursting charge of rifle powder.; 13 8	0 00	
Sept. 1	1034		3 10	1⅝		13 4; 4 bursting charge of rifle powder.; 13 8	0 00	Wind from right, 10 miles an hour; barometer, 30.22; thermometer, 81°; humidity, 61.
Sept. 1	1035		3 10	1⅝		13 4½; 3½ bursting charge of rifle powder.; 13 8	0 00	
Sept. 1	1036		3 10	1⅝		13 4½; 3½ bursting charge of rifle powder.; 13 8	0 00	
Sept. 1	1037		3 10	1⅝		13 4; 4 bursting charge of rifle powder.; 13 8	0 00	
Sept. 2	1038		3 10	2		13 4; 4 bursting charge of rifle powder.; 13 8	0 00	Wind from front and left, 30° 22 miles an hour; barometer, 30.13; thermometer, 73°; humidity, 78.
Sept. 2	1039		3 10	1⅝		13 4; 4 bursting charge of rifle powder.; 13 8	0 00	
Sept. 2	1040		3 10	1⅝		13 4; 4 bursting charge of rifle powder.; 13 8	0 00	

Sandy Hook Proving Ground, from August 30 to September 2, 1897—Continued.

Special remarks about each fire, such as effect on piece, action of breech mechanism, consumption of powder, sound of projectile in flight, scattering of fragments, etc.	General remarks.
Burst after passing through the target, probably due to the percussion action.	
Burst 100 feet short of target. Following hits on target: Bullets through .... 159 Fragments through .... 84 Fragments embedded .... 51 Total 294	
Burst 80 feet short of target. Following hits on target: Bullets through .... 145 Fragments through .... 101 Fragments embedded .... 52 Total 298	
Burst 90 feet short of target. Following hits on target: Bullets through .... 160 Fragments through .... 154 Fragments embedded .... 114 Fragments made mark .... 2 Total 430	
Burst 225 feet short of target..........	
Burst 200 feet short of target..........	
Burst 225 feet short of target..........	
Burst 2 feet short of target..........	
Burst 160 feet short of target..........	
Burst 200 feet short of target..........	Firing conducted by Lieut. G. Montgomery, Ordnance Department; Frank Heath, Captain, Ordnance Department, U. S. A., commanding; George Montgomery, Lieutenant, Ordnance Department, U. S. A., assistant proof officer.

-pnel. Round № 1004.

front of Target.



APPENDIX 23.

REPORT OF THE PRINCIPAL OPERATIONS AT THE BENICIA ARSENAL.

BENICIA ARSENAL, CAL., *August 10, 1897.*

SIR: I have the honor to submit the following report of the principal operations at this arsenal during the fiscal year ending June 30, 1897:

FIREPROOF BOILER HOUSE.

A new fireproof boiler house has been built on the plans on file in your office.

On digging for a foundation it was found unnecessary to use piling, as originally proposed. Rock was first put in the trenches, and, after tamping, was capped with several feet of concrete. On this brick walls 12 inches thick and 13 feet 6 inches high were erected. There has been no yielding, and it is thought the structure is remarkably rigid. The dimensions of the building are: Height, 62 feet; width, 41 feet. The roofing is made of Thorn's metallic shingles, and proves very satisfactory. The building contains, besides four 40-horsepower boilers, space enough for a tin shop and for pipe-cutting machines. Total cost of building, including foundations, $2,500.

PROVING GROUND.

Work on a new proving ground was begun last fall, under the direction of Lieutenant Lissak, by installing a 12-inch B. L. mortar and preparing a firing butt by cutting into a hill situated about 300 feet in front of the gun and laying bare a vertical wall of soft adobe rock to receive the projectile.

The firing of this gun caused the abandonment by Lieutenant Lissak of the plan of installing modern guns of 8, 10, or 12 inch caliber at this point, but the installation of platforms, etc., for field and siege guns, as planned by him, has been carried out.

During the wet season it was found that the marshy ground on which the target screens are placed was impassable, and a causeway has been run across from guns to butt.

Platforms are now arranged for field guns, for 8-inch converted rifle, and for 12-inch B. L. mortar, and if a pintle be placed for the siege carriages, the latter can be used on the field-gun platform. In detail the work thus far done on proving ground is as follows:

Buildings.—Instrument house, 12 by 12 feet, of brick, 55 feet to the left and rear of gun, protected by embankment. Loading house, 12 by 12 feet, of light wood; double doors and windows, 110 feet to the left and rear of gun, and protected by natural bank.

Platforms.—12-inch B. L. mortar, of 12 by 12 inch timbers, securely bolted and anchored; 8-inch converted rifle, same; field and siege guns, concrete platform 30 by 15 feet by 18 inches.

Butts.—A cut made 45 feet perpendicularly into face of hill; lateral walls retained to stop any splinters.

Target screens.—Crib walk of 10 by 10 inch pine has been laid for targets. Targets not yet completed.

Fabricated.

Gatling-gun carts repaired	4
Tripods for Gatling gun repaired	2
Vent pieces, 6-pounder gun	3
Vent pieces, 3-inch gun	2
Vent piece, 3.2-inch rifle	1
Vent pieces, light 12-pounder gun	6
Vent cover, 3-inch rifle	1
Carriage for 3.2-inch gun painted	1
Iron scrapers for cannon	12
Wooden spring sponge for 12-inch B. L. rifle	1
Wooden spring sponge for 10-inch B. L. rifle	1
Gunners' quadrants repaired	3
Breech sights, M. L. converted rifle, repaired	4
Dummy projectiles for 12-inch B. L. rifle	6
Cartridges, 12-inch B. L. rifle, 90-pound charge	56
Dummy cartridges for 12-inch B. L. rifle	6
Primer bags made and filled	50
Cartridge bags filled, 3.2-inch gun, 1½-pound charge	1,800
Cartridge bags filled, 12-pounder gun, 1-pound charge	1,000
Cartridge bags filled, 6-pounder gun, 1-pound charge	3,095
Cartridge bags filled, 3-inch gun, 1-pound charge	1,000
Cartridge bags filled, 12-inch B. L. rifle, 87-pound charge	8
Cartridge bags filled, 12-inch B. L. rifle, 76-pound charge	12
Cartridge bags filled, 12-inch B. L. rifle, 45¾-pound charge	6
Cartridge bags filled, 12-inch B. L. rifle, 115-pound charge	32
Streamers for target practice	12
Half blocks, oak, 8 by 4 by 20 inches	10
Quarter blocks, oak, 3 by 4 by 20 inches	10
Blocks, pine, 12 by 12 by 44 inches	60
Blocks, pine, 12 by 6 by 44 inches	12
Blocks, oak, 12 by 4 by 44 inches	20
Blocks, oak, 12 by 2 by 44 inches	18
Blocks, oak, 12 by 1 by 44 inches	18
Roller chocks	20
Gun chocks	10
Way planks	12
Rollers 7 inches diameter, 6 feet long	20
Hand cart	1
Floating targets, without floats	2
Floating target, complete, except chain and anchor	1
Holdfasts, iron, for holding capstan	4
Holdfasts, iron, 4½ feet long	4
Holdfasts, iron, 3 feet long	4
Brinton target, 6 by 12 feet, complete	1
Halliards for streamers	4
Pulley block repaired	1
Sling chains altered	2
Sling cart painted	1
Hydraulic jacks repaired	4
Cartridge bags, unfilled, 12-inch B. L. rifle, 76-pound charge	30
Cartridge bags, unfilled, 12-inch B. L. rifle, 45¾-pound charge	20
Cartridge bags, unfilled, 12-inch B. L. rifle	66
Cartridge bags, unfilled, 10-inch B. L. rifle	54
Cartridge bags, unfilled, 6-pounder gun	45
Cartridge bags, unfilled, 15-inch S. B. gun, 130-pound charge	32
Cartridge bags, unfilled, 10-inch S. B. gun, 25-pound charge	20
Hollow stem for compressor of pneumatic dynamite battery	1
Sponges, woolen, light 12-pounder gun	24
Sponges, woolen, 6-pounder gun	12
Spindle and nut, gas check cup, for 3.2-inch B. L. rifle, rebushed	1
Leather linchpin washers	12

For Brinton targets, 6 by 12 feet:	
Stay rods	12
Eyebolts	24
Slide rods	24
Top plates for slide rods	12
Bottom plates for slide rods	12
Fastening hooks	12
Sash cord, 12 feet long	12
Main sills	6
Top beams	6
Cross sills	12
Posts	12
Braces	12
Pulleys and fittings	12
Bolts, 28 inches long	24
Drip pans, copper, large	8
Drip pans, copper, small	4
Drip pans, copper, with perforated stands	3
Blacking, for leather ... quarts..	100
Black wax ... pounds..	50
Paint, lead color ... do....	50
Paint, black ... do....	533
Paint, first coat, for 3.2-inch rifle ... do....	1½
Paint, second coat, for 3.2-inch rifle ... do....	1½
Paint, olive ... do....	4,933
Paint, red ... do....	2
Paint, white ... do....	2
Paint, brown metallic ... do....	1,000
Lacquer, No. 1 ... gallons..	85
Harness oil ... pounds..	1,000
Putty ... do....	20
Packing boxes	290
Tin cans, 5-pound	10
Tin cans, 25-pound	3
Tin cans, 1-gallon	10
Pails, galvanized iron	2

Other work done.

Cavalry saddles overhauled and cleaned	25
Gun slings overhauled and cleaned	1,330
Carrying braces cleaned and oiled	993
Curb bridles cleaned and oiled	150
Light cavalry sabers cleaned and oiled	1,555
Gatling guns cleaned and repaired	2
Hair cinches cleaned	1,040
Coat straps cleaned	1,523
Blanket shoulder straps cleaned	500
Haversack straps cleaned	450
Sword belts, N. C. O., cleaned	729
Shells for 3.2-inch rifle filled	25
Two-inch pipe laid for water system of post ... linear feet..	525
Board fence built ... rods..	106
New plank walk laid ... linear feet..	2,180
Fence repaired ... do....	3,175
Picket fence built ... feet..	55
Plank walk relaid and repaired ... linear feet..	1,500
Concrete walk built in front of officers' quarters ... square feet..	4,325
Road repaired ... rods..	130
Road built to proving ground ... do....	20
New flooring laid in detachment quarters ... feet..	1,800
Water pumped from bay to reservoir ... gallons..	5,405,000

Exterior of lumber shed, post exchange, and paint shop painted. New flanges, rings, and valves put in steam pump, and new drum put on boiler of steam pump for pumping water to reservoir. Tunnel to main reservoir repaired, inner end filled with concrete, and timbered to its entrance. Telegraph poles made and erected, and 8,000 feet of

wire put up for electrical system of post. Old smokestack at pump house taken down and replaced by new one. New furnaces put in office and quarters No. 2. Lead pipe of soft-water system removed in quarters Nos. 1, 2, and 4 and replaced by galvanized-iron pipes; lead tanks disconnected and connections made by galvanized-iron pipes with wooden tanks in rear of quarters. Cisterns from main shops connected by galvanized-iron pipe with the above wooden supply tank. Elevating arc put on one 12-inch B. L. rifle. Three pent houses built for pneumatic dynamite-gun battery near Fort Winfield Scott. Side sights put on three 12-inch B. L. rifles. Stiffening ribs fitted to two 10-inch disappearing carriages; loading platform extended, cranes straightened, and railing and steps placed on two barbette carriages for 12-inch B. L. rifle; direction plates put on two 10-inch disappearing gun carriages; elevating apparatus and steps to loading platform adjusted on 12-inch barbette carriages at battery near Fort Winfield Scott. New translating studs put in 12-inch breech blocks, and trays adjusted to blocks of 12-inch B. L. rifles at Forts Winfield Scott and Baker. Breech sight of 12-inch B. L. rifle No. 10 at Fort Baker seated and trunnion-sight seat drilled and threaded. Water system of post, roads, drains, walks, public grounds, trees, and vines kept in order. Buildings, fences, wind mills, machinery, wagons, carts, tools, and harness repaired and kept in order. Public animals kept shod. Two hundred and seventy-nine issues of ordnance stores have been made from this arsenal, and 124 invoices of ordnance stores have been received at this arsenal, making a total of 403 receipts and issues.

Respectfully submitted.

L. S. BABBITT,
Lieutenant-Colonel, Ordnance Department, U. S. A., Commanding.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

(10097—Enc. 5)

APPENDIX 24.

TESTS OF CHARCOAL AND SMOKELESS POWDERS AT BENICIA ARSENAL FROM SEPTEMBER 1, 1896, TO AUGUST 31, 1897.

Work on the new proving ground has been continued during the year. Approaches to the new ground, causeway across marsh, and cribs for screens completed, and cut in opposite hill to serve as target enlarged. Also 8-inch converted rifle and platform installed and concrete firing platform for field gun laid. A brick instrument house and a light wooden loading house completed. Drawings for light iron screen frames have been made and the work thereon is now being done at the arsenal shops.

The original plan of installing 8-inch, 10-inch, and 12-inch B. L. rifles at the proving ground has been abandoned as unfavorable, and therefore, as in the past, powders for these guns will be tested at the Presidio of San Francisco.

No new smokeless powders have been submitted for test since last report, though a number of lots, similar to those previously submitted, have been tested.

The Giant Powder Company which, a year ago, installed a testing plant at considerable expense, has abandoned the attempt of making smokeless powder, although the last lot tested very nearly fulfilled the Government requirements, and failed only in the moisture test. This action is supposed to be the result of a private agreement between several rival high explosive works on this coast by which a disastrous cut rate war was settled. It is believed that the powder made by the Giant Powder Works is practically identical in composition with that made by the California Powder Works (known as the Peyton), but lacked its ballistic qualities through want of proper treatment.

After the receipt of the 3.2-inch B. L. rifle, adapted to metallic ammunition, several tests were made with powder furnished by the United States Smokeless Powder Company; also one test with Giant smokeless, adapted to the same gun.

Two lots of powder designated in last report as "Italian smokeless," were tested. The representative of the inventors claimed ignorance of the composition of this powder. The color of the smoke on flashing, and its flashing when treated with sulphuric acid, showed it to be a chlorate mixture. Late correspondence with the representative showed such a lack of even the rudiments of the ballistics of powder that further tests were abandoned.

CHARCOAL POWDERS.

A lot of 40,000 pounds saluting powder for the 3.2 and 3.6 inch rifled field guns and a lot of 10,000 pounds for S. B. seacoast guns were inspected at the California Powder Works August 14, 1897, and proved

early in September at this arsenal. With this exception the only charcoal powders tested were those submitted under contract for the 10-inch and 12-inch B. L. rifles by the California Powder Works, represented by Mr. Bernard Peyton.

Brown prismatic powder for 12-inch B. L. rifle.

[Contract of December 5, 1895. Requirements: Maximum charge, 490 pounds; projectile, 1,000 pounds; maximum pressure, 38,000 pounds per square inch; muzzle velocity, 2,025 feet per second.]

Date of test.	Charge.	Projectile.	Velocity.	Pressure per square inch.	Remarks.
	Pounds.	*Pounds.*	*Ft. sec.*	*Pounds.*	
Nov. 13, 1896	490	1,000	2,111	40,835	Residue great in both cases. Accepted.
Do......	465	1,000	2,043	37,350	

Brown prismatic powder for 10-inch B. L. rifle.

[Contract of December 2, 1895: 10-inch B. L. rifle, mounted on Buffington-Crozier disappearing carriage No. 2. Requirements: Maximum charge, 280 pounds; projectile, 575 pounds; muzzle velocity, 2,025 feet per second; maximum pressure, 38,000 pounds per square inch.]

Date of test.	Charge.	Projectile.	Velocity.	Pressure per square inch.	Remarks.
	Pounds.	*Pounds.*	*Ft. sec.*	*Pounds.*	
Feb. 8, 1897	186	575	Lost.	16,950	
Do......	250	575	1,870	33,500	First screen short circuited by spectator joining wires.
Do......	280	575	Lost.	43,650	
Feb. 9, 1897	270	575	1,982	38,200	Fired to test carriage only.
Do......	250	575	....	30,200	
Do......	280	....	2,025	43,100	Rejected.

The above firing was also to test the working of the gun carriage, and for that purpose the elevation of the gun had to be changed, causing considerable delay in arranging screens. The precipitous nature of the ground in the immediate front of the batteries at the Presidio makes it difficult to erect screens. In this case the uprights were over 30 feet high.

During loading, etc., the parapets were thronged with people and the record of the third shot was lost by some one accidentally joining two loose wires. Recent orders forbidding the presence of all unauthorized persons should do away with such annoyances in future.

In May a second lot of 10-inch powder was submitted, but was rejected for lack of uniformity.

SMOKELESS POWDERS.

GIANT SMOKELESS.

The following table contains results of tests conducted under Lieut. O. M. Lissak, Ordnance Department:

[Except where noted, F. A. shell and E_{36} primer were used.]

Powder.	Charge.	Projectile.	Velocity at 50 feet.	Pressure per square inch.	Date of test.	Remarks.
	Grains.	*Grains.*	*Ft. sec.*	*Pounds.*		
M 23 C	36	220	....	37,830	Sept. 17, 1896	Pressure mean of 12 shots.
Giant smokeless	42	220	1,994	39,250	Oct. 9, 1896	Winchester primer 2½ W., F. A. shell and bullet.
Do	41	220	1,908	37,150	....do....	
Do	41	220	1,890	35,880	....do....	
Do	40	220	1,794	37,370	....do....	Winchester shell and bullet.
Do	40	220	1,852	37,180	....do....	Winchester shell and F. A. bullet.
Do	40	220	2,036	....	....do....	Fired for velocity only. Previous shots, velocity, and pressures taken together.
B powder	41	220	....	45,800	Oct. 12, 1896	Mean of 5 shots.
Do	39	220	....	39,100	....do....	
M 23 C	36	220	....	43,720	....do....	

March 24, 1897, Mr. Hasselmeier, representing the Giant Powder Company, presented a sample of small-arms powder for test.

This powder, marked E, was in cylindrical grains 0.084 inch long and 0.053 inch diameter, uniform in size of grain, and well glazed. Mr. Hasselmeier stated it was pressed and cut by machine, and had approximately the following composition: 40 per cent nitroglycerin, 40 per cent nitrocellulose (hydro-nitrocellulose), and 20 per cent ammonium picrate, to which was added 2 per cent of oxide of zinc and one-half per cent lampblack.

By more perfect treatment it was claimed that the defects of previous powders had been overcome.

The following table sets forth the result of tests made thereon:

[Frankford Arsenal shell and bullet.]

Date of test.	Charge.	Velocity at 50 feet.	Mean variation.	Extreme variation.	Pressure per square inch.	Mean variation.	Extreme variation.	Remarks.
	Grains.	*Ft. sec.*			*Pounds.*			
Mar. 24, 1897	40	....	....	....	36,000	....	....	
Do	41	....	....	....	37,150	....	....	
Do	42	....	....	....	37,000	....	....	
Do	43	2,105	....	....	39,000	....	....	
Mar. 27, 1897	*a* 43	2,141	7.6	13	38,550	940	1,300	Mean of 5 shots.
Do	*a* 42	2,093	14	30	37,200	480	650	
Mar. 30, 1897	*a* 42	2,098	23	42	37,045	655	2,855	Mean of 10 shots. Standard for heat and moisture tests.

a Velocity and pressure taken separately.

Several hang fires occurred, usually accompanied by loss in velocity. The greater variations, when 42 grains were fired, is believed to be due to the fact that the powder did not fill the case. With 43 grains the case was completely filled.

When exposed for twenty-four hours in closed vessel over water the following results were obtained:

Date of test.	Charge.	Velocity at 50 feet.	Mean variation.	Extreme variation.	Variation from standard.	Pressure per square inch.	Remarks.
	Grains.	*Ft. sec.*				*Pounds.*	
	42	2,098	30	100	....	37,045	Standard.
Apr. 9, 1897	42	1,980	34	69	118	Less than 35,000	Mean of 10 shots.
Apr. 17, 1897	42	1,972	18.5	62	126	Less than 35,000	Mean of 10 shots.

(No coppers of less than 35,000 initial compression on hand.)

When exposed for twenty-four hours to a temperature of 130° F. the following results were obtained:

Date of test.	Charge.	Velocity at 50 feet.	Mean variation.	Extreme variation.	Variation from standard.	Pressure per square inch.	Mean variation.	Extreme variation.	Remarks.
	Grains.	*Ft. sec.*				*Pounds.*			
Apr. 9, 1897	42	2,055	30.8	44	43	37,300	690	1,100	Pressure mean of 5 shots. Velocity mean of 10 shots.

From the above it will be seen that this powder failed, as when tested at Frankford Arsenal previously, in its ability to withstand exposure to moisture. (The small amount of powder submitted prevented more extended firing.)

During these tests notice was received that the Giant Powder Works had abandoned making smokeless powder. On April 16 Mr. Hasselmeier, in his individual capacity, submitted a lot of what has previously been designated as "Giant smokeless," adapted for field gun using metallic ammunition. The composition was as mentioned before. It was in the form of rods 6.25 inches long and 0.222 inch in diameter, and was unglazed.

Following is the result of firing:

[3.2-inch B. L. rifle, metallic ammunition, Gerdom mechanism.]

Date of test.	Charge.	Projectile.	Velocity at 100 feet.	Pressure per square inch.	Remarks.
	Ounces.	*Pounds.*	*Ft. sec.*	*Pounds.*	
Apr. 16, 1897	12	16½	1,080	Less than 15,000	1 ounce black powder priming.
Do......	16	16½	1,300	20,600	1 ounce black powder priming.
Do......	18	16½	1,451	22,900	1 ounce black powder priming.

Owing to small quantity submitted, no supplementary tests were made. The lack of glazing, and the relative roughness of the rods, would doubtless cause a greater variation under the moisture test than was the case with the small-arms powder.

ITALIAN SMOKELESS.

[Submitted by Mr. Gabriel, of San Jose, representing the inventors.]

The first received was in three lots, marked "A" special, "B" special, and "C" special, all of irregular grain, with a mean diameter of 0.04, 0.10, and 0.15 inch, respectively.

The following are some of its characteristics: White, friable, flashes easily and violently, giving off quantities of white smoke, with purple tinge, indicating presence of potassium salt; residue considerable, not sensitive to shock or friction; rusts gun very badly.

[Frankford Arsenal shell and bullet.]

Kind of powder.	Date of test.	Charge.	Velocity at 50 feet.	Pressure per square inch.	Remarks.
		Grains.	*Ft. sec.*	*Pounds.*	
"A" special	Feb. 24, 1897	35	1,502	Less than 35,000	Mean of 2 shots.
Do	do	37	1,597	37,250	
"B" special	do	37	1,583	36,050	
Sample D	Mar. 2, 1897	37	....	46,400	Second lot marked D & E.
Do	do	35	....	36,200	
Do	do	36	1,586	40,570	
Sample E	do	36	1,547	39,400	

Later three more lots marked "A" special, "B" special, and "C" special were received. As the granulation was entirely too large for the small arm, the agent kindly notified this arsenal in his letter of transmittal that the grains could be broken up to suit the inspector. Samples not tested.

UNITED STATES SMOKELESS.

All the powders submitted by this company are intended for the field gun and are largely the metallic salts of picric acid; the general composition being about: 30 per cent barium picrate, 60 per cent ammonium picrate, 10 per cent picric acid.

In all, three lots of varying composition were tried. The powder was in the form of dark yellow spherical pellets, hard on the exterior, but breaking up rather easily when the outer skin was cracked. Following is result of firing:

Date of test.	Kind of powder.	Charge.	Projectile.	Velocity at 100 feet.	Pressure per square inch.	Remarks.
			Pounds.	*Ft. sec.*	*Pounds.*	
Feb. 11, 1897	Sample "A," 5/8 mesh.	10 ounces smokeless, 1 ounce priming.	16½	1,038	26,000	Present: Mr. T. Hopkins, president United States Smokeless Powder Company and Mr. Starke, chemist.
Do	Sample "A," 6/7 mesh.	do	16½	Lost.	19,600	
Do	Sample "A," 7/8 mesh.	do	16½	Lost.	24,600	
Do	Sample "A," 6/7 mesh.	12 ounces smokeless, 1 ounce priming.	16½	1,140	36,400	
Mar. 3, 1897	Sample "B," 3/4 mesh.	12 ounces smokeless, ½ ounce priming.	16½	1,058	17,750	
Do	do	16 ounces smokeless, ½ ounce priming.	16½	1,124	24,600	
Do	Sample "B," 1/8 mesh.	do	16½	1,221	24,700	
Do	do	18 ounces smokeless, ½ ounce priming.	16½	1,261	29,200	
Do	Sample "B," 5/8 mesh.	16 ounces smokeless, ½ ounce priming.	16½	1,268	24,150	
Do	do	18 ounces smokeless, ½ ounce priming.	16½	1,361	34,200	
Apr. 13, 1897	Sample "C," 3/8 mesh.	do	16½	1,411	53,200	

The samples "A," "B," and "C" varied in composition. The behavior of this powder was not satisfactory. There always appeared a critical pressure below which the combustion was slow and incomplete and the integrity of the grain was maintained, but above which the explosion was violent, with sudden and great rise in pressure without corresponding gain in velocity. It is my opinion that at this pressure the grain was broken up and the explosion partook of the nature of an explosion of a higher order.

The inspection of smokeless powders made by the California Powder Works is still in progress. None of this powder is to be tested here, and as the manufacture is confidential, it will be embodied in separate report.

Respectfully submitted.

E. B. BABBITT,
Lieutenant, Ordnance Department, U. S. A.

BENICIA ARSENAL, CAL., *August 31, 1897.*

(17188—Enc. 3)

APPENDIX 25.

REPORT OF THE INSPECTOR OF POWDER.

OFFICE OF THE INSPECTOR OF POWDER, U. S. A.,
Wilmington, Del., September 9, 1897.

SIR: I have the honor to submit, in compliance with your instructions, the following report of this office for the year ending June 30, 1897:

The installation of the proving ground connected with this office remains as stated in my last annual report. All the pieces have been in use during the past year.

CHARCOAL POWDERS.

No new work in this line has been entered on during the year, but contractors have been engaged in furnishing powders under contracts already in existence. The apparently certain adoption of smokeless powder throughout our service in the near future reduces the importance of this branch of the subject, but it is, nevertheless, intended to have it on a systematic and well-organized footing, so that recourse to it could be had in case of necessity. The presses, plates, etc., necessary for the production of the entire series of powders required for the pieces in service are on hand and ready for use.

SMOKELESS POWDERS.

My last report states that when nitroglycerin is used under certain conditions there appears to be no objection to its employment in powder, but that, on the other hand, there are decided advantages on the score of high ballistics and economy. These conclusions were drawn from general information and from the results of the experiments with five smokeless-powder compositions described in my last annual report. These experiments, which were still in progress when that report was made, were completed during the past year, except those involving long storage, and the results are only confirmatory of the conclusions derived from the earlier and principal portion of the series of experiments.

It was then decided to investigate more fully the compositions composed essentially of nitrocellulose and nitroglycerin, and to make the experiments with cannon powders for the service guns. Accordingly, three compositions were selected, all of the type designated "NN" (nitrocellulose-nitroglycerin), which are designated and described as follows:

NN (130-10); nitrocellulose yielding 13 per cent of nitrogen, the powder containing 10 per cent of nitroglycerin.

NN (12-25); nitrocellulose yielding 12 per cent of nitrogen, the powder containing 25 per cent of nitroglycerin.

NN (11-40); nitrocellulose yielding 11 per cent of nitrogen, the powder containing 40 per cent of nitroglycerin.

These compositions were regarded as including the practicable variations within the type, and as producing only allowable erosion and

heating effects. The question of the form of granulation was also to be decided. The Maxim Powder and Torpedo Company succeeded in granulating a portion of the above range of compositions in their "multiperforated" form, which is regarded as possessing decided advantages, but those of the more india-rubber-like consistency had proved too refractory, and there seemed to be a question whether the composition most suitable in other respects would prove amenable to the most suitable granulation. As granulation is a mechanical process, it was thought well to interest private manufacturers in the solution of the problem, and this course was adopted.

To continue the development on the lines indicated above contracts were awarded to the Du Pont Company, the Laflin & Rand Powder Company, and the California Powder Company for powder for field guns, 12-inch mortars, and 10-inch B. L. rifles. The compositions were prescribed as those stated above, but the form of granulation was left to the manufacturers. By this means it is expected to obtain a comparison of the effects of these compositions in several forms of granulations, strips, thin squares, tubular, and multiperforated. These powders are now being delivered and tested at the proving ground in the execution of the current work in place of the brown powder that would otherwise be required, and when the test of the series is completed the results will, it is hoped, furnish sufficient information to warrant the adoption of approximately the most suitable composition and form of grain.

This investigation is mainly devoted to the NN type of composition, but others are not excluded, and it is intended that the results obtained with this type shall be compared with the best obtainable from other types before it is regarded as completed. In pursuance of this policy orders have been given to the California Powder Works for a sample lot for the 8-inch B. L. rifle of the "Peyton" composition, to the Laflin & Rand Powder Company for a sample lot for the same gun of "W.-A." composition, one to the American Ordnance Company for a sample lot for 10-inch B. L. rifle of one of the best foreign compositions, and also one to the Du Pont Company for a special form of grain of the NN type.

Manufacture of the above-mentioned powders has progressed sufficiently to show that any of the forms of granulation above mentioned can be satisfactorily produced in each of the compositions prescribed, but the testing has not at this writing proceeded so far as to enable final comparisons to be made among the different compositions and forms of grain.

For more than two years this office has endeavored through its relations with private manufacturers to further the development of the "multiperforated" form of grain. The advantages of this form were first theoretically set forth by General Rodman, but it was impracticable to realize them in the charcoal powders. To the Maxim Powder and Torpedo Company belongs the credit of having revived the idea and applied it practically to the colloidal smokeless-powder compositions. At my instigation the study of this form was taken up by the Du Pont Company about two years ago, and the results obtained confirm by practical trial the theoretical conclusions, and indicate the ballistic superiority of this form over any other yet produced. Other considerations may in particular cases outweigh this ballistic superiority, and the definite determination of the relative values of the various conditions that affect the question is one of the principal objects of the experiments just mentioned.

With the old charcoal powders it was customary, when an increase of velocity was desired without an increase of the maximum pressure, to use slower powder and increase the charge; and there was hardly a limit, except size of chamber, to which this method could not be carried with beneficial results as respects the velocity. But such a limit is easily reached with the smokeless powders, burning by parallel surfaces as they do, and granulated in forms favorable to progressive combustion. This was well shown by two series of experiments made for the determination of the most suitable thickness of grain for the 3.6-inch field and 7-inch siege mortars. The grains were in the form of thin squares, three-eighths inch on an edge for the field mortar and three-fourths inch for the siege mortar. The composition was practically the same throughout. The thickness of the grains was not very uniform throughout a sample, and the value given in each case is the mean of several taken at random. The charge given is, for each sample, that giving a maximum pressure of 15,000 pounds per square inch in the field mortar, or 18,000 pounds in the siege mortar. The weights of the projectiles were, respectively, 20 and 125 pounds. The relation of the quickness and charge to the velocity are shown in the following table:

3.6-inch field mortar.			7-inch siege mortar.		
Thickness.	Charge.	Velocity.	Thickness.	Charge.	Velocity.
Inch.	*Ounces.*	*Feet per sec.*	*Inch.*	*Ounces.*	*Feet per sec.*
0.021	6.5	680	0.026	36	750
.026	7.5	680	.030	42	780
.032	9.0	665	.035	47	793
.039	9.7	655	.045	54	773

For this granulation the increase variation in thickness affects somewhat the progressiveness, while the use of grains too thick to be consumed in the gun practically causes a reduction of the chamber space through the inclusion therein of useless material.

The Peyton composition is now used for the service powders for the .30-caliber magazine rifle and gives good satisfaction. The Laflin & Rand Powder Company is anxious to produce a powder along the lines of its W.-A. powders for this piece. The powders so far produced show some points of relative advantage and some of relative disadvantage in comparison with the "Peyton" composition. In order to aid and expedite the development of this powder an order has been placed with this company, under which it is now experimenting with a view to decreasing the objectionable features.

The question of adopting a suitable smokeless powder for the .45-caliber Springfield rifle with which the National Guard is being armed has been investigated during the year. It is not difficult to reproduce the results obtained with black powder, and with the 500-grain bullet the recoil is so great as to preclude an increase of velocity sufficiently great to warrant resighting the store of arms. But if the old 405-grain bullet be employed we are enabled by the use of smokeless powder to employ a very considerable higher velocity than that given by black powder. The question of most suitable weight of bullet is thus reopened and experiments for its solution are now in progress.

In conclusion, the only smokeless powder actually adopted as yet for service use is the "Peyton" powder for the .30-caliber magazine rifle, at present manufactured by the Du Pont Company and the California Powder Company. But we have progressed sufficiently with the

development for other calibers to determine powders for them all that give excellent results, far better than those obtainable from charcoal powders, and near to the best that can be expected from smokeless powder. The object of further delay in formally adopting standard powder for service use is to secure first the highest practicable qualities and thus avoid subsequent change.

INSPECTION OF POWDER.

During the year the following contracts and orders have been in process of execution under my inspection:

With E. I. Du Pont de Nemours & Co.:

(1) Order dated September 23, 1894, for 500 pounds smokeless powder for 8-inch B. L. rifle.

(2) Contract dated December 2, 1895, for 26,000 pounds black sphero-hexagonal powder for siege cannon and 12-inch mortars; 65,000 pounds brown prismatic for 12-inch mortars; 90,000 pounds for 8-inch B. L. rifle; 120,000 pounds for 10-inch B. L. rifle, and 202,000 pounds for 12-inch B. L. rifle.

(3) Order dated May 20, 1896, for 200 pounds smokeless powder for 3.6-inch and 7-inch mortars.

(4) Contract dated May 26, 1896, for 25,000 pounds black sphero-hexagonal powder for 15-inch S. B. gun.

(5) Contract dated February 17, 1897, for 11,000 pounds of smokeless powder in experimental lots for various cannon.

(6) Several small orders from Sandy Hook Proving Ground for experimental smokeless shell powders and high explosives.

(7) Several small orders from Frankford Arsenal for experimental smokeless small-arms powders.

With the Maxim Powder and Torpedo Company:

(8) Contract dated January 13, 1896, for 850 pounds smokeless powder for special tests.

With the Laflin & Rand Powder Company:

(9) Order dated March 11, 1897, for 50 pounds experimental smokeless powder for .30-caliber rifle.

(10) Contract dated June 5, 1897, for 5,000 pounds experimental smokeless powder for .30-caliber rifle.

With Atlantic Dynamite Company:

(11) Contract dated June 26, 1896, for 1,500 pounds Emmensite.

At the close of the fiscal year Nos. 3, 6, 7, 8, 9, and 11 had been completed.

Under these orders and contracts the following amounts have been delivered during the year:

	Pounds.
For small arms, smokeless	65
For 3.2-inch field gun, smokeless	3,530
For 3.6-inch field mortar, smokeless	35
For 7-inch siege mortar, smokeless	165
For 12-inch mortars, brown	23,277
For 12-inch mortars, smokeless	700
For 8-inch B. L. rifle, brown	16,400
For 10-inch B. L. rifle, brown	63,450
For 10-inch B. L. rifle, smokeless	2,000
For 12-inch B. L. rifle, brown	12,000
For shells, smokeless for .30-caliber rifle	430
For shells, gun cotton	13
For shells, Emmensite	1,500

Very respectfully, your obedient servant,

SIDNEY E. STUART,
Captain, Ordnance Department, U. S. A., Inspector.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

(10394—Enc. 6)

APPENDIX 26.

PROGRESS REPORT OF MANUFACTURE OF STEEL FORGINGS, ETC., AT MIDVALE STEEL WORKS, PHILADELPHIA, PA., DURING THE FISCAL YEAR ENDING JUNE 30, 1897.

MIDVALE STEEL WORKS,
Philadelphia, Pa., September 1, 1897.

SIR: I have the honor to transmit the following report upon the operations undertaken for the Ordnance Department, United States Army, by the Midvale Steel Company for the fiscal year ended June 30, 1897.

All information relative to manufacture is omitted from this report upon the request of the Midvale Steel Company. The right to make this request is granted in the specifications embodied in the contracts, and all information given by the company is to be considered as confidential, and for the use of the Department only.

List of fabrications.

STEEL FORGINGS.

No. of contract or order.	Date of contract or order.	Date of expiration of contract or extension of contract.	Fabrication.
1	Aug. 14, 1896	June 4, 1899	21 sets steel forgings for 12-inch B. L. rifle, model 1895.
2	May 5, 1897	June 2, 1898	7 sets steel forgings for 12-inch B. L. rifle, model 1895.
3	Aug. 13, 1896	Feb. 7, 1898	8 sets steel forgings for 12-inch B. L. R. mortar, model 1886-90 M_1.
4	.....do	.....do	6 sets steel forgings for 12-inch B. L. R. mortar, model 1890 M_1.
5	May 1, 1897	Apr. 30, 1898	30 sets steel forgings for 12-inch B. L. R. mortar, model 1890 M_1.
6	Dec. 4, 1896	Mar. 18, 1898	20 sets steel forgings for 7-inch B. L. siege mortar, model 1892.
7	.....do	Apr. 22, 1898	30 sets steel forgings for 3.2 inch B. L. R. field gun, model 1890.
8	Aug. 15, 1896	Immediate ..	1 extra hoop A_1 for 12-inch B. L. rifle, model 1896.
9	.....do	.....do	1 extra set breech mechanism for 12-inch B. L. rifle, model 1895.
10	Jan. 9, 1897	.....do	1 jacket-locking hoop for 5-inch R. F. gun.
11	June 28, 1896	.....do	1 carrier ring, 1 breech block, for 5-inch R. F. gun.
12	Aug. 14, 1896	Jan. 15, 1897	115 8-inch steel A. P. shot, large core.
13	.....do	Mar. 15, 1897	205 10-inch steel A. P. shot, large core.
14	.....do	Jan. 16, 1897	100 12-inch steel A. P. shot, large core.
15	.....do	Apr. 2, 1897	225 10-inch steel A. P. shot, small core.
16	.....do	July 3, 1897	375 12-inch steel D. P. shell, 800 pounds.
17	.....do	Feb. 13, 1897	105 12-inch steel D. P. shell, 1,000 pounds.
18	.....do	Apr. 6, 1897	247 12-inch steel torpedo shell, 800 pounds.
19	.....do	Nov. 24, 1897	247 12-inch steel torpedo shell, 1,000 pounds.
20	Sept. 19, 1896	Oct. 21, 1896	1 steel tray casting for 12-inch B. L. rifle, model 1896. 1 steel hinge block for 12-inch B. L. rifle, model 1896.
21	Feb. 11, 1897	Immediate ..	100 forged steel bars, 57 inches long, for 400 traversing rollers.
22	Apr. 13, 1897	.....do	10 steel tray castings for 10-inch B. L. rifle, model 1895. 14 steel tray castings for 12-inch B. L. rifle, model 1895. 1 steel hinge plate for 10-inch B. L. rifle, model 1895.
23	Aug. 10, 1897	.....do	101 steel billets for Watertown Arsenal.
24	Aug. 5, 1896	Aug. 5, 1897	1 10-inch Howell counterpoise gun carriage.

OUTSIDE WORK.

Under this head are comprised fabrications made at works other than those of the Midvale Steel Company.

STEEL FORGINGS AND STEEL CASTINGS.

No. of contract or order.	Date of contract or order.	Date of expiration of contract or extension of contract.	Fabrication.
			MADE BY THE WM. CRAMP & SONS SHIP AND ENGINE BUILDING CO., PHILADELPHIA, PA.
25	Nov. 5, 1894	June 5, 1895	1 10-inch spiller pneumatic disappearing carriage.
26	Oct. 21, 1895	Nov. 30, 1895	1 3.2-inch limited-recoil Driggs field carriage.
			MADE BY PENN IRON CO., LANCASTER, PA.
27	Aug. 13, 1896	Immediate	228 wrought-iron bars, 5 by 1-inch section, for Robt. Poole & Son Co.
28	Sept. 8, 1896 Sept. 20, 1896	.....do	191 wrought-iron bars, assorted sizes, for Southwark Foundry and Machine Co.
29	May 10, 1897	.....do	140 wrought-iron bars, 5 by 1-inch section, for Robt. Poole & Son Co.
			MADE BY CHAS. SCOTT SPRING CO., OF PHILADELPHIA, PA.
30	Aug. 14, 1896	Feb. 13, 1896	1,425 coiled steel springs for Robt. Poole & Son Co.
31	Sept. 7, 1896	.....do	250 coiled steel springs for Southwark Foundry and Machine Co.
32	May 5, 1897	.....do	875 coiled steel springs for Robt. Poole & Son Co.
33	May 10, 1897	.....do	375 coiled steel springs for American Hoist and Derrick Co.
			MADE BY PHILADELPHIA ROLL AND MACHINE CO.
34	Nov. 20, 1896	.....do	190 gun iron castings for 12-inch mortar and 10-inch disappearing carriages.
			MADE BY PENN STEEL CASTING CO., CHESTER, PA.
35	Mar. 16, 1896	Immediate ..	215 steel castings for 10-inch disappearing carriage for Watertown Arsenal.
36	Sept. 7, 1896 Jan. —, 1897	.....do	102 steel castings for 12-inch Emery elevating gun carriage for A. H. Emery.
37	Jan. 19, 1897	.....do	288 steel castings for 8-inch disappearing carriage, model 1894, for Morgan Engineering Co.
38	Jan. 25, 1897	.....do	103 steel castings for 10-inch Howell counterpoise carriage for West Point Foundry.
39	Apr. 12, 1897	May 14, 1897	24 steel castings for 12-inch barbette carriage (altered gun lift) for Watertown Arsenal.
40	Feb. 8, 1897	Immediate..	12 steel castings for 10-inch ammunition truck for Watertown Arsenal.
41	July 12, 1897	.....do	388 steel castings for 10-inch disappearing carriage, L. F., model 1896, for Watertown Arsenal.
42	July 31, 1897	Sept. 30, 1897	112 steel castings for 5-inch barbette carriage, model 1896, balanced pillar mount for Watertown Arsenal.
			MADE BY AMERICAN STEEL CASTING CO., THURLOW, PA.
43	June 16, 1896	Sept. 14, 1896	30 steel castings for 12-inch disappearing carriage for Watertown Arsenal.
44	July 1, 1896	Immediate ..	26 steel castings for 12-inch barbette carriage for Watertown Arsenal.
45	.....do	Oct. 27, 1896	140 steel castings for 8-inch disappearing carriage for Watertown Arsenal.
46	Dec. 1, 1896	Immediate ..	6 steel castings for 12-inch shot truck for Watertown Arsenal.
47	Sept. 14, 1896	.....do	180 steel castings for 7-inch mortar carriage, model 1892, for Watertown Arsenal.
48	.....do	.....do	40 steel castings for 3.6-inch mortar carriage for Watertown Arsenal.
49	Jan. 1, 1897	.....do	420 steel castings for 8-inch disappearing carriage, model 1894, for Providence Steam Engine Co.
50	Jan. 14, 1897	.....do	300 steel castings for 8-inch disappearing carriage, model 1896, for Pond Machine Tool Co.
51	Feb. 15, 1897	.....do	390 steel castings for 8-inch ammunition truck for Pond Machine Tool Co.
52	Extra order	.....do	90 steel castings for 8-inch disappearing carriage, model 1896, for Pond Machine Tool Co.
53	.....do	.....do	117 steel castings for 8-inch ammunition truck for Pond Machine Tool Co.
54	Mar. 5, 1897	.....do	360 steel castings for 8-inch ammunition trucks for Watertown Arsenal.
55	Mar. 20, 1897	.....do	2 steel castings for 5-inch R. F. gun carriage for Watertown Arsenal.
56	June 9, 1897	2 months....	2 steel castings for 10-inch chassis, L. F., model 1894, for Watertown Arsenal.
57	June 16, 1896	Immediate ..	140 steel castings for 12-inch disappearing carriage for Watertown Arsenal.
58	June 28, 1897	.....do	396 steel castings for 10-inch disappearing carriage, model 1896, for Niles Tool Works.

Steel forgings and steel castings—Continued.

No. of contract or order.	Date of contract or order.	Date of expiration of contract or extension of contract.	Fabrication.
			MADE BY CAMBRIA IRON CO., JOHNSTOWN, PA.
59	June 22, 1897	Immediate..	241 steel forgings for 12-inch Emery elevated gun carriage, for A. H. Emery.
60	.....do	.....do	24 steel forgings for 12-inch Emery elevated gun carriage, for A. H. Emery.
61	June 24, 1897	.....do	75 steel forgings for 12-inch Emery elevated gun carriage, for A. H. Emery.
62	July 21, 1897	.....do	1 steel forging for 12-inch Emery elevated gun carriage, for A. H. Emery.
63	Aug. 2, 1897	.....do	2 steel forgings for 12-inch Emery elevated gun carriage, for A. H. Emery.
			MADE BY BENJ. ATHA & ILLINGWORTH CO., NEWARK, N. J.
64	Aug. 13, 1896	Immediate..	2,621 steel forgings for 12-inch mortar carriage, model 1896, for Robt. Poole & Son Co.
65	.....do	.....do	2,109 steel castings for 12-inch mortar carriage, model 1896, for Robt. Poole & Son Co.
66	Sept. and Oct., 1896.	.....do	519 steel forgings for 12-inch mortar carriage, model 1896, for Southwark Foundry.
67	.....do	.....do	270 steel castings for 12-inch mortar carriage, model 1896, for Southwark Foundry.
68	.....do	.....do	1,227 steel forgings for 10-inch disappearing carriage, L. F., model 1896, for Southwark Foundry.
69	.....do	.....do	480 steel castings for 10-inch disappearing carriage, L. F., model 1896, for Southwark Foundry.
70	Sept. 30, 1896	.....do	576 steel forgings for 10-inch disappearing carriage, L. F., model 1896, for Niles Tool Works.
71	.....do	.....do	312 steel castings for 10-inch disappearing carriage, L. F., model 1896, for Niles Tool Works.
72	Dec. 11, 1896	.....do	1 chassis casting for 10-inch disappearing carriage, L. F., model 1894, for Kilby Manufacturing Co.
73	Dec. 22, 1896	.....do	3 chassis castings for 10-inch disappearing carriage, L. F., model 1894, for Kilby Manufacturing Co.
74	.....do	.....do	94 steel forgings for 10-inch disappearing carriage, L. F., model 1894, for Kilby Manufacturing Co.
75	June 5, 1897	.....do	9 steel forgings for 10-inch disappearing carriage, L. F., model 1894, for Kilby Manufacturing Co.
76	Mar. 16, 1897	.....do	798 steel forgings for 8-inch disappearing carriage, L. F., model 1894, for Morgan Engineering Co.
77	No date given.............		695 steel forgings for 8-inch disappearing carriage, L. F., model 1896, for Pond Machine Tool Co.
78	.....do.....................		296 steel forgings, extra order, for 8-inch disappearing carriage, L. F., model 1896, for Pond Machine Tool Co.
79	May 5, 1897	Immediate..	403 steel castings for 12-inch mortar carriage, model 1896, for Providence Steam Engine Co.
80	.....do	.....do	1,185 steel forgings for 12-inch mortar carriage, model 1896, for Providence Steam Engine Co.
81	May 10, 1897	Dec. 15, 1897	1,295 steel castings for 12-inch mortar carriage, model 1896, for Robt. Poole & Son Co.
82	.....do	.....do	1,820 steel forgings for 12-inch mortar carriage, model 1896, for Robt. Poole & Son Co.
			MADE BY CROWN SMELTING CO., CHESTER, PA.
83	Jan. 27, 1897	Immediate..	1,098 bronze castings for 8-inch disappearing carriage, L. F., model 1894, for Morgan Engineering Co.
84	June 10, 1897	.....do	324 bronze castings for 8-inch disappearing carriage, L. F., model 1894, for Morgan Engineering Co.
85	Feb. 10, 1897 Mar. 13, 1897	.....do	61 bronze castings for 8, 10, and 12 inch rifle and 12-inch mortar for Watervliet Arsenal.
86	Feb. 10, 1897	.....do	1,472 bronze castings for 8-inch disappearing carriage, model 1896, for Pond Machine Tool Co.
87	Extra order.	.....do	430 bronze castings for 8-inch disappearing carriage, model 1896, for Pond Machine Tool Co.
88	.....do	.....do	645 bronze castings (small) for 8-inch disappearing carriage, model 1896, for Pond Machine Tool Co.
89	June 3, 1897	.....do	156 bronze castings for 8 inch disappearing carriage, model 1896, for Pond Machine Tool Co.
90	Mar. 5, 1897	.....do	66 bronze castings for 10-inch disappearing carriage, L. F., model 1896, for Southwark Foundry.
91	Sept. 1, 1897	.....do	90 bronze castings for 12-inch mortar carriage, model 1896, for American Hoist and Derrick Co.
92	Sept. 8, 1897	.....do	36 bronze consoles for 12-inch mortar for Watervliet Arsenal.
			MADE BY SOUTHWARK FOUNDRY AND MACHINE CO., PHILADELPHIA, PA.
93	Aug. 17, 1896	Feb. 1, 1898	10 12-inch spring return mortar carriages, model 1896.
94	.....do	Mar. 12, 1898	10 10-inch disappearing carriages, L. F., model 1896.

Of the above list the following numbers have been completed: Nos. 3, 4, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 35, 36, 37, 38, 39, 40, 43, 44, 45, 46, 47, 48, 51, 54, 55, 59, 60, 62, 64, 65, 66, 67, 70, 72, 73, 74, 75, 76, 77, 83, 84, 85, 88, and 89.

The stores represented by these numbers have been shipped to their respective destinations.

The unfinished work at the date of this report comprises Nos. 1, 2, 5, 6, 16, 19, 32, 33, 34, 41, 42, 49, 50, 52, 53, 56, 57, 58, 61, 63, 68, 69, 71, 78, 79, 80, 81, 82, 86, 87, 90, 91, 92, 93, and 94.

No. 24, 10-inch Howell carriage, in above list was completed, as far as this station is concerned, by transfer to the inspector at West Point Foundry.

References to the finished and unfinished work will be found under appropriate headings.

I.—12-INCH B. L. RIFLE, MODEL 1895.

(*a*) CONTRACT OF AUGUST 14, 1896.

This contract is for 21 sets of steel forgings. Eight complete sets of forgings and all the breech mechanism except the breechblocks have been shipped to Watervliet Arsenal. The eighth set is not due until December 5, 1897, but was delivered June 25, 1897, or 5 months and 10 days before due.

(*b*) CONTRACT OF MAY 5, 1897.

Seven sets of steel forgings are to be made under this contract. Preliminary work only has been done. The first set will be due on September 5, 1897, but will not be delivered on that date.

II.—12-INCH B. L. R. MORTARS (STEEL).

(*a*) CONTRACT OF AUGUST 13, 1896.

This contract was for 14 sets of steel forgings—8 sets of model 1886–90 M_1 and 6 sets of model 1890 M_1. The eighth or last set of model 1886–90 M_1 was delivered April 3, 1897. The 8 sets of this model were shipped to Watervliet Arsenal The sixth or last set of model 1890 M_1 was delivered July 2, 1897. The 6 sets of this model were shipped to the Builders Iron Foundry, Providence, R. I.

The contract of August 13, 1896, will expire on February 7, 1898; hence the contract was filled 7 months and 5 days in advance of the date of expiration, and without penalty.

(*b*) CONTRACT OF MAY 1, 1897, 30 SETS, MODEL 1890 M_1.

Of the 30 sets of 12-inch mortar forgings to be made under the above-mentioned contract, 9 complete sets have been shipped, viz, 5 sets to the Builders Iron Foundry, Providence, R. I., and 4 sets to Niles Tool Works, Hamilton, Ohio.

All the forgings for the 30 sets of breech mechanism except 2 breechblocks and 2 spindles have been shipped to their respective destinations.

To prevent confusion, all the odd numbers between Nos. 15 and 43, both inclusive, have been or will be shipped to the Builders Iron Foundry, while all the even numbers from Nos. 16 to 44, both inclusive, have been or will be shipped to Niles Tool Works.

The company took this contract on short time; delivery of first set in 45 days from date of contract and 1 set every 11 days thereafter.

Penalties were deducted for delay in the delivery of the first 5 sets for 29, 24, 21, 14, and 8 days, respectively. Penalty for 5 days' delay was also deducted from the price of the seventh set.

The sixth, eighth, and ninth sets were delivered on time, without penalty.

III.—7-INCH B. L. R. SIEGE MORTAR, MODEL 1892.

CONTRACT OF DECEMBER 4, 1896.

This contract is for 20 sets of 7-inch mortar forgings. Ten sets have been completed at the date of this report, all within the time specified by the contract.

Eight complete sets and all the forgings for the breech mechanism of the remaining 12 sets have been shipped to Watervliet Arsenal.

IV.—3.2 INCH B. L. RIFLE, MODEL 1890.

CONTRACT OF DECEMBER 4, 1896.

The 30 sets of forgings for the 3.2-inch field guns were all finished April 19, 1897, or 1 year and 3 days in advance of the date of expiration of contract, April 22, 1898.

This was an exceptionally fine lot of forgings. All were shipped to Watervliet Arsenal.

V.—MISCELLANEOUS FORGINGS, ETC.

The following miscellaneous forgings and castings have been made by the Midvale Steel Company for the Department since date of last report, viz: one extra hoop A_1 for 12-inch B. L. rifle, model 1896; 1 extra set of breech mechanism for 12-inch B. L. rifle, model 1895; 1 jacket-locking hoop for 5-inch R. F. gun; 1 carrier ring for 5-inch R. F. gun; 1 breechblock for 5-inch R. F. gun; 1 hinge block for 12-inch B. L. rifle, model 1896; 1 hinge plate for 10-inch B. L. rifle, model 1895; 1 steel tray casting for 12-inch B. L. rifle, model 1896; 10 steel tray castings for 10-inch B. L. rifle, model 1895; 14 steel tray castings for 12-inch B. L. rifle, model 1895.

All the above forgings and castings were shipped to Watervliet Arsenal.

One hundred steel forgings 8 inches diameter and 57 inches long were made and shipped to Robert Poole & Son Company. One hundred and one steel billets of various sizes were made for Watertown Arsenal.

VI.—ARMOR-PIERCING SHOT.

[Contract of August 14, 1896.]

(a) 8-INCH STEEL A. P. SHOT, LARGE CORE.

There were 115 A. P. shot of this caliber, which were tested successfully in 2 lots and were completed and shipped April 27, 1897. A penalty was exacted for 2 days' delay on the last lot.

(b) 10-INCH STEEL A. P. SHOT, LARGE CORE.

There were 205 A. P. shot of 10-inch caliber tested in 3 lots, which were all finished and shipped by July 29, 1897. The first lot failed on ballistic test, was re-treated, and passed the second ballistic test. The second lot incurred a penalty for 6 days' delay. One extra shot was made and accepted, making a total of 206 projectiles.

(c) 12-INCH STEEL A. P. SHOT, LARGE CORE.

There were only 100 of these projectiles. They were tested in 2 lots, finished, and shipped March 6, 1897. The second lot incurred a penalty for 23 days' delay in delivery.

(d) 10-INCH STEEL A. P. SHOT, SMALL CORE.

The 225 shot of this kind and caliber were divided into 3 lots for ballistic test. The first 2 lots were tested against an 11¼-inch tempered nickel plate and the last lot against a 10-inch harveyized and reforged steel plate.

One extra shot was made and accepted.

These shot were finished July 23, 1897.

All the above 4 kinds of projectiles (unbanded) were shipped to Watervliet Arsenal, except those for ballistic tests, which were sent to Sandy Hook Proving Ground, N. J.

The entire contract was completed July 29, 1897.

VII.—12-INCH MORTAR SHELL.

[Contract of August 17, 1896.]

(a) 12-INCH D. P. SHELL—800 POUNDS.

Three lots of these shell have been tested, finished, and shipped to Watervliet Arsenal.

The second lot was delivered on time, but the first and third lots incurred a penalty for a delay of 4 and 7 days, respectively.

The fifth and sixth lots will be delivered within the contract time.

(b) 12-INCH D. P. SHELL—1,000 POUNDS.

The 2 lots of these projectiles have been tested, finished, and sent to Watervliet Arsenal. There was a delay of 17 days on the second lot.

(c) 12-INCH TORPEDO SHELL—800 POUNDS.

These were divided into 4 lots for ballistic test, and have all been completed and shipped to Watervliet Arsenal.

The first and second lots incurred a penalty for a delay of 2 and 7 days, respectively.

(d) 12-INCH TORPEDO SHELL—1,000 POUNDS.

Two lots of these shell have been tested, accepted, and shipped to Watervliet Arsenal.

The other two lots are not yet due, but will probably be submitted on time.

VIII.—10-INCH HOWELL COUNTERPOISE GUN CARRIAGE.

The contract dated August 5, 1896, for this carriage was transferred to the inspector at the West Point Foundry, where the carriage is being erected.

IX.—OUTSIDE WORK.

All material made at points other than the Midvale Steel Works is classed as "outside work." The inspector stationed here had charge of the inspection of material for the Ordnance Department, U. S. A.,

at the following works, viz: (1) William Cramp & Sons' Ship and Engine Building Company, Philadelphia, Pa.; (2) Penn Iron Company, Lancaster, Pa.; (3) Charles Scott Spring Company, Philadelphia, Pa.; (4) Philadelphia Roll and Machine Company, Philadelphia, Pa.; (5) Penn Steel Casting Company, Chester, Pa.; (6) American Steel Casting Company, Thurlow, Pa.; (7) Cambria Iron Company, Johnstown, Pa.; (8) Benj. Atha & Illingworth Company, Newark and Harrison, N. J.; (9) Crown Smelting Company, Chester, Pa.; (10) Southwark Foundry and Machine Company, Philadelphia, Pa.

The details of these fabrications are given below, and in the "list of fabrications" at the head of this report.

(1) WILLIAM CRAMP & SONS' SHIP AND ENGINE BUILDING COMPANY.

(*a*) *One Spiller pneumatic disappearing carriage for 10-inch B. L. rifle.*

(*b*) *Three and two-tenths inch limited recoil field carriage (Driggs system).*

These two carriages were made under the direction of Capt. H. D. Borup, Ordnance Department, U. S. A., and have both been shipped to Sandy Hook, N. J.

(2) PENN IRON COMPANY.

(*a*) *Order of Robert Poole & Son Company, dated August 13, 1896.*—This order called for 228 wrought-iron bars 5 by 1 inch in section for distance rings for 12-inch mortar carriages, model 1896. The order was completed October 22, 1896.

(*b*) *Order of Southwark Foundry and Machine Company, dated September 8–30, 1896.*—This was for 191 bars of wrought iron, assorted sizes, for use in erecting 12-inch mortar carriages. It was completed October 22, 1896.

(*c*) *Order of Robert Poole & Son Company, dated May 10, 1897.*—The 140 wrought-iron bars, 5 by 1 inch, on this order were furnished and tested June 16, 1897.

(3) CHARLES SCOTT SPRING COMPANY.

(*a*) *Order of Robert Poole & Son Company, dated August 14, 1896.*—This order, for 1,425 coiled steel springs for 12-inch mortar carriages, was completed on time.

(*b*) *Order of Southwark Foundry and Machine Company, dated September 7, 1896.*—There were 250 coiled steel springs under this order, and all were promptly completed and shipped.

(*c*) *Order of Robert Poole & Son Company, dated May 5, 1897.*—This order, for 875 coiled steel springs, is for use in 12-inch mortar carriages. The first set of springs is due September 15, 1897, and 200 per month thereafter.

(*d*) *Order of American Hoist and Derrick Company, of St. Paul, Minn., dated May 10, 1897.*—This order is for 375 coiled steel springs, to be used in the construction of 12 inch mortar carriages. The first set of 25 springs was due and was delivered August 1, 1897. The contract calls for 50 springs per month after first set.

There will be no trouble about the prompt delivery of these springs.

The Charles Scott Spring Company are especially energetic, and their work is very satisfactory indeed in material, workmanship, and quality.

It is the intention to make a special report on these springs at a future date.

(4) PHILADELPHIA ROLL AND MACHINE COMPANY.

Gun iron castings for 12-inch mortar and 10-inch disappearing carriages.

There were 170 castings for 12-inch mortar carriages and 20 castings for retraction chain drums for 10-inch disappearing carriages, model 1896, ordered from this firm by the Southwark Foundry and Machine Company.

The gun iron castings for the mortar carriages are completed, except 2 racers and some replacements.

For 10-inch retraction chain drums, 32 castings have been made to get 20, and 7 will have to be replaced on account of blowholes.

Considerable difficulty has been experienced in getting these castings.

(5) PENN STEEL CASTING COMPANY.

All the steel castings for 10-inch ammunition trucks and 12-inch barbette carriages (altered gun lift) made for Watertown Arsenal, for 10-inch Howell counterpoise gun carriage made for West Point Foundry, for 12-inch Emery elevating gun carriage made for Mr. A. H. Emery, C. E., and for 8-inch disappearing carriage, L. F., model 1894, made for Morgan Engineering Company, have been completed and shipped to their respective destinations.

The 7 castings for 10-inch disappearing carriages made for Watertown Arsenal and referred to in last report have been completed.

The steel castings for 5-inch barbette carriage, model 1896, balanced pillar mount, and for the 10-inch disappearing carriage, L. F., model 1896, all for Watertown Arsenal, are in progress and will probably be finished within a few months.

(6) AMERICAN STEEL CASTING COMPANY.

The steel castings for 8-inch disappearing carriages, for 12-inch barbette carriages, and for 12-inch disappearing carriages (type) remaining unfinished at date of last report have been finished and shipped to Watertown Arsenal.

The steel castings for 3.6-inch mortar carriages, 7-inch mortar carriages, model 1892, 12-inch shot trucks, 8-inch ammunition trucks, 5-inch R. F. carriage, all for Watertown Arsenal, have been completed.

The Watertown Arsenal order for two 10-inch chassis rails needs one chassis to complete the order.

All the castings for the 12-inch disappearing carriages made for Watertown Arsenal have been cast and most of them shipped. Two half racers remain to complete the original order, one of which is about ready for submission and the other has been condemned for flange broken in knocking off sinking head. Four of the gun levers and six elevating slides have been condemned for defects developed in machining and will have to be replaced. Two of these gun levers are already cast.

The castings for the 8-inch disappearing carriages, L. F., model 1894, ordered by the Providence Steam Engine Company, of Providence, R. I., have all been finished except 2 racers and 2 chassis, and one of each of these has been cast.

The steel castings for the 8-inch disappearing carriages, L. F., model 1896, and 8-inch ammunition trucks, ordered by the Pond Machine Tool Company, are three-fourths completed, and should be finished within two months.

The Pond Machine Tool Company's first order is completed except 2 gun levers, which have been cast. Their second is now in progress.

The steel castings for the 10-inch disappearing carriage, model 1896, ordered by the Niles Tool Works, are in progress and will probably be finished within a few months. Eighty-five of these castings have been accepted.

(7) Cambria Iron Company.

Of the 343 steel forgings ordered from this company by Mr. A. H. Emery, C. E., for 12-inch Emery elevating gun carriage, 266 have been accepted and shipped to the Niles Tool Works, Hamilton, Ohio, leaving 77 yet to be furnished.

(8) Benjamin Atha & Illingworth Company.

The steel forgings and steel castings for 12-inch mortar carriages, model 1896, on Robert Poole & Son Company's first order have been completed.

The forgings on Robert Poole & Son Company's second order for 12-inch mortar carriage are finished except 8 piston rods, 10 crank pins, and 302 traversing rollers. About one-third of the steel castings on Robert Poole & Son Company's second order have been shipped.

The steel forgings for 8-inch disappearing carriage, L. F., model 1894, made for Morgan Engineering Company, and the steel forgings and steel castings for 10-inch disappearing carriage, L. F., model 1894, made for Kilby Manufacturing Company, have been finished and shipped.

Of the Niles Tool Company's order for material for 10-inch disappearing carriage, L. F., model 1896, all the steel forgings and all the steel castings except 4 have been finished.

The Southwark Foundry and Machine Company's order for material for 12-inch mortar carriage, model 1896, has been completed, and on their order for material for 10-inch disappearing carriage, L. F., model 1896, all the pieces have been accepted except 5 forgings and 3 gun-lever castings. There are also 4 gun levers and a few minor castings and forgings to be replaced.

The Providence Steam Engine Company's order for 12-inch mortar carriage, model 1896, forgings has been filled except 9 sets of traversing rollers.

The same company's order for mortar carriage castings is in progress, and is about one-third completed.

The steel forgings for 8-inch disappearing carriage, model 1896, ordered by the Pond Machine Tool Company, are completed except 27 forgings, viz, 3 piston rods and 24 suspension rods.

(9) Crown Smelting Company.

The Crown Smelting Company have finished and shipped the bronze castings for the first order from Watervliet Arsenal and for the Morgan Engineering Company's order.

Of the bronze castings for the other orders placed with this company the number of castings still due is as follows, viz:

	Castings.
On Southwark Foundry and Machine Company's order	1
On Pond Machine Tool Company's first order	6
On Pond Machine Tool Company's second order	218
On American Hoist and Derrick Company's order	82
On Watervliet Arsenal's second order	36

These should be completed within two months.

10. SOUTHWARK FOUNDRY AND MACHINE COMPANY.

[Contracts dated August 17, 1896.]

(*a*) *10-inch disappearing carriage, L. F., model 1896.*—Two of these carriages, Nos. 9 and 10, have been completed and shipped.

Carriage No. 9 was originally due January 17, 1897, and was submitted for shop trial June 1, 1897, a delay of 135 days. Its final delivery was further delayed until June 21, 1897, to make change in retraction gear ordered by the Department.

Carriage No. 10 was originally due March 17, 1897, and was delivered August 24, 1897, a delay of 160 days.

The third, fourth, fifth, and sixth carriages were due May 1, June 1, June 15, July 30, and September 13, 1897, respectively.

The company applied for an extension of contract, but the decision has been held in abeyance to see what progress the company could make in completing carriages and anticipating the deliveries of the later carriages.

The company hope to deliver the third and fourth carriages (Nos. 11 and 12) during the first 10 days in October, 1897.

(*b*) *12-inch mortar carriages, model 1896.*—Three 12-inch mortar carriages have been delivered and shipped.

The first 12-inch mortar (No. 58) was originally due January 17, 1897; the time was extended 45 days to March 3, 1897, and was delivered June 1, 1897, a delay of 90 days. The final delivery was further delayed by waiting for templet for elevating rack, to be furnished by the United States.

The second carriage (No. 59) was originally due February 28, 1897; the time was extended 30 days to March 30, 1897, and was finally delivered September 2, 1897, a delay of 156 days.

The third carriage (No. 60) was originally due April 11, 1897; the time was extended 30 days to May 11, 1897, and was finally delivered September 9, 1897, a delay of 121 days.

The fourth carriage (No. 61) was originally due May 23, 1897; the time was extended 30 days to June 22, 1897, and the company expect to deliver it about October 1, 1897.

All the material for the gun carriages except a few pieces for the last three carriages, and all the material for the mortar carriages except the last two carriages, has been delivered.

The few pieces due on each should not delay the work.

It is not prudent at this time to predict the rate of future deliveries of these carriages.

X.—SHIPMENTS, ETC.

The numbers and weights of steel forgings and steel castings that have been shipped under the supervision of this station are given in tabular form below.

These tables do not include the pieces nonaccepted or condemned, which increase considerably the number of pieces whose record must be kept.

The enormous amount of clerical work involved may be faintly conceived when it is noted that 26,172 pieces, weighing 8,209,571 pounds, have been recorded, tested, and shipped.

A total of 6,083 test bars have been broken and the results recorded.

In addition, there have been 1,517 summary reports of tests sent out, 646 letters and 461 indorsements written, 205 letters of acceptance for material tested, and 73 invoices, in duplicate, made out.

WEIGHTS OF STEEL CASTINGS.

Designation.	Shipped from–	Aggregate weight.
		Pounds.
12-inch mortar spring-return and 10-inch disappearing carriages.	Benj. Atha & Illingworth Co., Newark, N. J.	1,020,655
12 inch, 10-inch, 8-inch disappearing, 12-inch barbette, 7-inch and 36-inch mortar carriages.	American Steel Casting Co., Thurlow, Pa.	1,174,963
10-inch, 8-inch disappearing, 12-inch and 5-inch barbette, 12-inch mortar, 12-inch Emery and 10-inch Howell disappearing carriages.	Penn Steel Casting and Machine Co., Chester, Pa.	662,094
12-inch and 10-inch shot trays	Midvale Steel Works	5,789
Total weight		2,863,501

WEIGHTS OF FORGINGS–MIDVALE.

Designation.	Aggregate weight.	Designation.	Aggregate weight.
	Pounds.		*Pounds.*
12-inch B. L. rifle	1,180,104	12-inch D. P. shell, 800 lbs	172,480
12-inch B. L. rifled mortar	851,404	12-inch D. P. shell, 1,000 lbs	100,594
7-inch B. L. siege mortar	23,125	12-inch torpedo shell, 800 lbs	171,418
3.2-inch B. L. rifle	38,631	12-inch torpedo shell, 1,000 lbs	108,625
12 inch A. P. shot, large core	95,400	Miscellaneous	212,797
10-inch A. P. shot, large core	114,500		
10-inch A. P. shot, small core	129,040	Total weight	3,231,068
8-inch A. P. shot, large core	32,950		

RECAPITULATION.

	Pounds.
Midvale Steel Works:	
Total weight of forgings shipped	3,231,068
Outside works:	
Atha & Illingworth Company, total weight of forgings shipped	1,210,043
Total weight of steel castings shipped as per table	2,863,501
Total weight of wrought-iron from Penn Iron Company	116,753
Total weight of steel forgings from Cambria Iron Company	49,959
Total weight of steel forgings from Scott Spring Works	214,979
Total weight of iron castings from Philadelphia Roll and Machine Company	451,027
Total weight of bronze castings from Crown Smelting Company	72,241
Total weight of castings and forgings	8,209,571
Midvale Steel Works:	
Number of forgings shipped	2,828
Number of castings shipped	25
Outside works:	
Number of forgings shipped by Benj. Atha & Illingworth Company	9,361
Number of castings shipped by Benj. Atha & Illingworth Company	3,859
Number of castings shipped by American Steel Casting Company	2,528
Number of castings shipped by Penn Steel Casting and Machine Company	681
Number of castings shipped by Philadelphia Roll and Machine Company	187
Number of pieces shipped by Scott Spring Works	3,498
Number of pieces shipped by Penn Iron Company	559
Number of pieces shipped by Cambria Iron Company	266
Number of pieces shipped by Crown Smelting Company	2,380
Total number of pieces shipped	26,172
Number of Midvale bars broken	2,405
Number of outside bars broken at Midvale from September 1, 1896, to September 1, 1897	3,678
Total	6,083

XI.—PHYSICAL TESTS.

The twelve tables appended, Tables A to L, both inclusive, give recapitulations of the tests of material made at the Midvale Steel Works during the past year.

Tables M and N give diagrams of the accepted material from all sources for the ten 12-inch mortar carriages, model of 1896, and ten 10-inch disappearing carriages, L. F., model 1896, now being made by the Southwark Foundry and Machine Company.

RECAPITULATION OF MAXIMUM, MEAN AND MINIMUM OF TENSILE TESTS.

TABLE A.—*Parts of 12-inch B. L. rifle.*

Name of piece.	Number tested.		Maximum.				Mean.				Minimum.			
	Pieces.	Bars.	Elastic limit per square inch.	Tensile strength per square inch.	Elongation.	Contraction of area.	Elastic limit per square inch.	Tensile strength per square inch.	Elongation.	Contraction of area.	Elastic limit per square inch.	Tensile strength per square inch.	Elongation.	Contraction of area.
			Pounds.	*Pounds.*	*Per cent.*	*Per cent.*	*Pounds.*	*Pounds.*	*Per cent.*	*Per cent.*	*Pounds.*	*Pounds.*	*Per cent.*	*Per cent.*
Tubes	8	50	60,000	93,600	25.80	54.40	47,500	87,000	20.40	40.50	40,000	78,440	16.40	24.50
Jackets	8	71	60,000	103,600	25.80	53.90	50,300	91,400	19.60	35.50	42,000	84,400	14.60	24.50
Trunnion hoops	8	32	60,000	104,400	21.50	61.30	55,100	99,500	19.10	54.00	49,000	96,000	16.70	22.30
Hoops A1	8	24	68,000	108,000	18.30	52.20	61,400	101,300	16.90	43.50	55,000	96,000	13.70	23.30
Hoops A2	8	48	69,000	113,040	21.60	54.10	58,400	101,250	16.90	42.60	50,000	94,000	12.00	17.60
Hoops A3	8	48	69,000	108,000	22.00	53.90	58,900	100,200	17.00	45.30	51,000	92,400	12.10	20.80
Hoops B2	8	65	67,000	111,370	21.00	55.10	58,500	101,700	17.30	45.60	50,000	92,640	12.50	22.70
Hoops B3	8	65	67,000	112,000	22.10	56.50	58,150	100,580	17.10	44.30	51,000	93,400	13.00	22.70
Hoops C1	8	50	64,000	112,160	21.30	53.20	57,400	100,020	17.90	39.70	50,000	93,600	14.50	21.40
Hoops C2	9	56	66,000	114,000	21.70	49.70	58,230	100,700	17.80	38.00	51.000	93,600	14.10	20.80
Hoops D	8	49	66,000	112,000	20.00	56.30	57,850	99,310	16.70	42.70	51,000	90,400	12.00	13.70
Breechblocks	5	11	53,000	104,800	22.60	51.00	50,900	97,300	20.80	44.50	48,000	93,200	17.80	32.00
Spindles	17	17	57,000	105.200	22.20	52.20	53,000	91,800	19.40	42.90	48,000	90,200	16.60	30.90
Hinge pins	7	7	64,000	107,200	24.80	60.40	56,700	97,520	21.30	55.10	53,000	92,000	18.80	49.70
Gas checks	8	16	88,000	143,200	15.00	37.80	80,450	139,200	12.60	32.60	77.000	135,200	10.30	27.60

TABLE B.—*Parts of 12-inch B. L. R. mortars.*

Name of piece.	Number tested.		Maximum.				Mean.				Minimum.			
	Pieces.	Bars.	Elastic limit per square inch.	Tensile strength per square inch.	Elongation.	Contraction of area.	Elastic limit per square inch	Tensile strength per square inch.	Elongation.	Contraction of area.	Elastic limit per square inch.	Tensile strength per square inch.	Elongation.	Contraction of area.
			Pounds.	*Pounds.*	*Per cent.*	*Per cent.*	*Pounds.*	*Pounds.*	*Per cent.*	*Per cent.*	*Pounds.*	*Pounds.*	*Per cent.*	*Per cent.*
Tubes	23	140	58,000	100,200	24.70	53.40	48,930	89,070	20.10	40.60	40,000	80,800	15.00	23.30
Jackets	23	200	63,000	106,800	26.90	57.00	50,900	91,380	19.70	40.80	42,000	80,400	14.20	20.50
Trunnion hoops	23	69	64,000	112,000	21.70	58.60	57,530	102,580	17.70	47.20	51,000	93,480	12.20	19.20
Hoops A1	7	30	68,000	111,600	21.60	55.30	59,130	101,090	17.30	45.00	51,000	96,000	12.40	20.20
Hoops A3	23	70	67,000	110,880	21.00	54.40	57,860	101,050	16.40	39.10	50,000	92,400	12.50	19.50
Hoops C	23	73	66,000	109,800	22.00	52.70	56,000	99,680	17.30	36.30	51,000	93,120	13.90	17.60
Hoops D	8	31	62,000	115,200	21.60	47.90	56,770	102,650	13.90	30.80	51,000	94,760	12.60	17.30
Breech bushings	12	39	61,000	106,400	22.00	49.20	57,080	100,410	17.80	37.20	52,000	95,600	14.60	27.60
Breechblocks	22	44	58,000	104,000	23.20	51.70	52,750	98,520	19.40	43.70	47,000	91,600	16.00	30.60
Spindles	24	24	56,000	105,000	25.80	55.10	52,080	96,130	20.50	44.00	47,000	83,200	16.40	30.60
Hinge pins	9	9	59,000	102,000	22.50	58.80	56,220	99,310	20.00	51.70	52,000	95,200	18.30	48.40
Gas checks	11	22	83,000	142,800	14.90	39.40	78,680	137,360	12.70	34.20	75,000	132,000	10.80	29.40
Trans. rollers	6	6	59,000	102,400	22.10	59.70	57,170	101,270	20.00	52.00	55,000	98,400	17.90	45.60
Face plates	15	15	50,000	94,800	27.00	56.00	45,210	87,710	22.40	49.60	41,000	76,600	17.00	42.20

TABLE C.—*Parts of 7-inch B. L. siege mortars.*

Name of piece.	Number tested.		Maximum.				Mean.				Minimum.			
	Pieces.	Bars.	Elastic limit per square inch.	Tensile strength per square inch.	Elongation.	Contraction of area.	Elastic limit per square inch.	Tensile strength per square inch.	Elongation.	Contraction of area.	Elastic limit per square inch.	Tensile strength per square inch.	Elongation.	Contraction of area.
			Pounds.	*Pounds.*	*Per cent.*	*Per cent.*	*Pounds.*	*Pounds.*	*Per cent.*	*Per cent.*	*Pounds.*	*Pounds.*	*Per cent.*	*Per cent.*
Gun body	10	41	55,000	99,600	22.70	52.70	51,390	92,450	19.50	39.30	47,000	87,080	16.70	27.00
Breech blocks	7	7	53,000	93,000	25.50	55.70	49,570	90,640	23.20	49.80	47,000	88,000	20.00	37.20
Spindles	8	8	61,000	100,500	30.50	62.30	54,750	93,750	27.30	60.10	49,000	87,500	25.00	55.50
Gas checks	4	4	87,000	139,000	17.20	44.00	85,250	138,060	16.80	43.60	83,000	137,250	16.50	43.40

TABLE D.—*Parts of 3.2-inch B. L. rifles.*

Name of piece.	Number tested.		Maximum.				Mean.				Minimum.			
	Pieces.	Bars.	Elastic limit per square inch.	Tensile strength per square inch.	Elongation.	Contraction of area.	Elastic limit per square inch.	Tensile strength per square inch.	Elongation.	Contraction of area.	Elastic limit per square inch.	Tensile strength per square inch.	Elongation.	Contraction of area.
			Pounds.	*Pounds.*	*Per cent.*	*Per cent.*	*Pounds.*	*Pounds.*	*Per cent.*	*Per cent.*	*Pounds.*	*Pounds.*	*Per cent.*	*Per cent.*
Tubes	30	122	64, 000	100, 900	29. 20	53. 30	48, 590	87, 740	23. 30	44. 10	41, 000	80, 900	19. 20	31. 50
Jackets	30	120	59, 000	105, 000	26. 40	56. 70	50, 830	96, 190	22. 20	42. 60	44, 000	87, 950	18. 00	30. 90
Breech blocks	7	6	52, 000	97, 000	22. 20	46. 60	48, 830	91, 670	19. 90	36. 10	47, 000	89, 000	18 10	30. 50
Spindles	6	6	55, 000	98, 500	25. 00	56. 50	49, 170	94, 500	23. 60	52. 70	45, 000	91, 400	22. 20	49. 20
Gas checks	7	7	88, 000	147. 000	15. 50	39. 40	87, 290	144, 650	14. 40	36. 60	86, 000	142, 500	13. 30	29. 90
Block carriers	3	3	50, 000	93, 500	22. 50	47. 50	48, 300	92, 500	21. 80	46. 50	47, 000	92, 000	20. 50	44. 90
Lever handles	3	3	57, 000	96, 000	26. 30	61. 10	55, 000	94, 170	25. 80	60. 20	52, 000	92, 000	25. 50	58. 30

TABLE E.—*Forgings—billets.*

Kind of steel.	Number tested.		Maximum.				Mean.				Minimum.			
	Pieces.	Bars.	Elastic limit per square inch.	Tensile strength per square inch.	Elongation.	Contraction of area.	Elastic limit per square inch.	Tensile strength per square inch.	Elongation.	Contraction of area.	Elastic limit per square inch.	Tensile strength per square inch.	Elongation.	Contraction of area.
			Pounds.	*Pounds.*	*Per cent.*	*Per cent.*	*Pounds.*	*Pounds.*	*Per cent.*	*Per cent.*	*Pounds.*	*Pounds.*	*Per cent.*	*Per cent.*
Steel No. 3	22	22	64, 500	108, 000	22. 20	47. 80	55, 430	99, 820	18. 10	30. 70	50, 000	92, 000	16. 00	19. 90

COMPARATIVE TABLE OF RESULTS OF TENSILE TESTS.

TABLE F.—*Parts of 12-inch B. L. rifle.*

Name of piece.	Year.	Number tested.		Mean.			
		Pieces.	Bars.	Elastic limit per square inch.	Tensile strength per square inch.	Elongation.	Contraction of area.
				Pounds.	*Pounds.*	*Per cent.*	*Per cent.*
Tubes	1895	6	39	46,820	83,600	22.18	42.48
	1896	5	30	46,300	86,170	21.13	39.12
	1897	8	50	47,500	87,000	20.40	40.50
Jackets	1895	6	48	50,145	89,395	21.18	42.37
	1896	5	40	51,150	93,410	21.45	43.00
	1897	8	71	50,300	91,400	19.60	35.50
Trunnion hoops	1895	6	24	54,333	98,000	20.10	49.54
	1896	5	20	54,920	98,800	19.35	48.37
	1897	8	32	55,100	99,500	19.10	54.00
Hoops A1	1895	8	24	56,042	99,354	17.57	44.00
	1896	3	9	54,777	96,430	18.81	49.77
	1897	8	24	61.400	101,300	16.90	43.50
Hoops A2	1895	6	18	57,000	99,400	19.06	42.85
	1896	5	30	56,700	99,110	16.95	41.72
	1897	8	48	58,400	101,250	16.90	42.60
Hoops A3	1895	6	36	56,444	95,690	17.26	45.80
	1896	5	30	57,400	98,670	18.09	44.01
	1897	8	48	58,900	100,200	17.00	45.30
Hoops B2	1895	6	40	55,700	97.940	15.80	37.13
	1896	5	39	54,420	101.200	16.69	40.00
	1897	8	65	58.500	101,700	17.30	45.60
Hoops B3	1895	6	26	57,577	101.735	16.28	38.76
	1896	5	20	58,150	101,120	16.61	38.33
	1897	8	65	58,150	100,580	17.10	44.30
Hoops C1	1895	9	54	56,666	98,960	18.76	37.80
	1896	2	12	55,606	97.360	17.37	34.45
	1897	8	50	57,400	100,020	17.90	39.70
Hoops C2	1895	7	44	56,932	99,382	18.32	39.15
	1896	4	24	56,500	98,150	18.22	39.92
	1897	9	56	58,230	100,700	17.80	38.00
Hoops D	1895	6	37	58,135	101,108	16.16	40.64
	1896	5	30	58,130	100,480	16.62	40.94
	1897	8	49	57,850	99,310	16.70	42.70

Table G.

STEEL CASTINGS MADE BY PENN STEEL CASTING AND MACHINE COMPANY, CHESTER, PA.

Designation of carriage.	Contract.	Number tested.		Maximum.				Mean.				Minimum.			
		Pieces.	Bars.	Elastic limit per square inch.	Tensile strength per square inch.	Elongation.	Contraction of area.	Elastic limit per square inch.	Tensile strength per square inch.	Elongation.	Contraction of area.	Elastic limit per square inch.	Tensile strength per square inch.	Elongation.	Contraction of area.
				Pounds.	*Pounds.*	*Per ct.*	*Per ct.*	*Pounds.*	*Pounds.*	*Per ct.*	*Per ct.*	*Pounds.*	*Pounds.*	*Per ct.*	*Per ct.*
Steel *a*, 12-inch Emery	Sept. 7, 1896	30	48	42,000	87,500	31.3	48.6	35,083	70,813	24.8	36.1	31,000	62,000	16.0	20.2
Steel No. 1, 8-inch disappearing	Jan. 19, 1897	67	120	43,000	80,000	32.2	51.1	37,127	68,651	26.2	39.7	31,500	62,000	15.0	21.3
Steel No. 2, 8-inch disappearing	do	18	18	40,500	78,000	29.0	46.9	37,472	73,972	24.6	37.0	35,500	69,000	20.0	22.0
Steel *b*, 10-inch Howell	Jan. 25, 1897	25	39	43,500	80,500	28.0	46.9	38,133	73,400	23.2	34.0	31,000	65,500	15.0	25.5
Steel No. 2, 12-inch mortar	June —, 1896	9	18	42,000	76,500	27.5	40.3	38,500	73,861	23.0	29.9	33,000	71,500	16.5	15.6
Gun levers.															
10-inch disappearing	Mar. 16, 1896	12	37	37,500	73,000	32.6	49.5	31,570	67,889	27.7	42.4	29,000	63,000	25.0	35.7
8-inch disappearing	Jan. 19, 1897	18	54	41,000	71,000	33.3	53.6	36,700	68,083	27.7	44.1	32,000	61,500	22.3	38.2

a Emery specifications, 60,000 to 70,000—15 per cent elongation.
b Howell specifications, 32,000 to 70,000—20 to 30 per cent elongation.

STEEL CASTINGS MADE BY MIDVALE STEEL WORKS, PHILADELPHIA, PA.

Steel No. 1, 10 and 12 inch tray castings.	Apr. 13, 1897	5	5	39,850	71,500	34.0	55.7	36,060	67,700	31.3	50.7	32,000	64,000	29.3	46.9

WROUGHT-IRON BARS MADE BY PENN IRON COMPANY, LANCASTER, PA.

Bars 5 by 1 inch (sec.)	Aug. 13, 1896	15	15	37,500	53,500	31.5	48.6	32,313	50,836	26.6	38.2	30,500	50,000	20.0	27.2
Bars 5 by 1 inch (sec.)	May 10, 1897	7	7	34,000	51,500	29.5	40.7	31,956	50,857	26.2	41.9	30,000	50,000	22.0	31.8

TABLE H.

STEEL CASTINGS MADE BY THE AMERICAN STEEL CASTING COMPANY, THURLOW, PA.

Designation of carriage.	Contract.	Number tested.		Maximum.				Mean.				Minimum.			
		Pieces.	Bars.	Elastic limit per square inch.	Tensile strength per square inch.	Elongation.	Contraction of area.	Elastic limit per square inch.	Tensile strength per square inch.	Elongation.	Contraction of area.	Elastic limit per square inch.	Tensile strength per square inch.	Elongation.	Contraction of area.
				Pounds.	*Pounds.*	*Per ct.*	*Per ct.*	*Pounds.*	*Pounds.*	*Per ct.*	*Per ct.*	*Pounds.*	*Pounds.*	*Per ct.*	*Per ct.*
Steel No. 1, 12-inch disappearing	June 16, 1896	17	30	38,000	74,000	33.7	48.9	31,325	67,300	27.6	40.8	26,500	61,250	19.8	23.1
Steel No. 1, 12-inch barbette	July 1, 1896	9	21	36,250	86,000	37.5	54.7	31, 20	68,000	28.6	44.6	29,000	62,500	25.0	36.3
Steel No. 2, 12 inch barbette	.....do	2	8	32,500	71,000	29.5	43.1	30,781	69,700	26.1	38.7	29,250	66,500	23.8	27.2
Steel No. 1, 8-inch disappearing	.....do	57	82	43,500	78,000	34.3	53.3	31,800	68,045	27.9	40.7	27,000	58,750	20.0	30.5
Steel No. 1, 7-inch mortar	Sept. 14, 1896	35	39	41,000	75,000	34.0	52.8	32,256	67,000	26.5	40.0	25,500	59,250	14.8	17.0
Steel No. 1, 8-inch disappearing	Jan. 1, 1897	53	80	39,000	87,500	35.0	60.4	32,486	66,972	27.2	41.0	26,000	61,000	15.5	17.0
Steel No. 2, 8-inch disappearing	.....do	16	16	47,500	80,000	33.7	54.1	39,075	70,625	24.4	39.3	34,500	71,000	19.6	26.5
Steel No. 1, 8-inch disappearing	Jan. 14, 1897	77	115	46,500	77,500	33.0	54.4	34,100	68,119	27.5	40.7	28,500	61,000	22.0	24.4
Steel No. 1, 12-inch disappearing	June 16, 1896	57	110	40,500	73,500	35.0	59.6	34,633	66,407	27.6	42.5	26,500	59,500	16.7	16.3
Gun levers of preceding contracts.															
12-inch disappearing	June 16, 1896	2	6	37,500	75,000	30.3	48.9	36,083	71,333	28.7	44.4	30,000	66,000	25.5	38.5
8-inch disappearing	July 1, 1896	10	32	35,000	74,000	32.5	51.4	31,668	68,110	25.7	45.1	29,000	59,500	23.8	39.7
8 inch disappearing	Jan. 1, 1897	12	36	40,500	76,000	33.0	51.7	35,130	68,666	28.1	43.8	30,000	61,500	23.5	37.9
8 inch disappearing	Jan. 14, 1897	18	54	44,000	73,000	37.0	55.5	33,133	66,000	29.9	47.0	25,000	60,000	24.9	36.6
12-inch disappearing	June 16, 1896	8	23	36,200	71,000	32.0	53.3	31,300	66,033	28.7	40.2	27,500	60,500	25.0	38.2

TABLE I.

STEEL CASTINGS MADE BY BENJ. ATHA & ILLINGWORTH COMPANY, NEWARK, N. J.

Designation of carriage.	Contract.	Number tested.		Maximum.				Mean.				Minimum.			
		Pieces.	Bars.	Elastic limit per square inch.	Tensile strength per square inch.	Elongation.	Contraction of area.	Elastic limit per square inch.	Tensile strength per square inch.	Elongation.	Contraction of area.	Elastic limit per square inch.	Tensile strength per square inch.	Elongation.	Contraction of area.
				Pounds.	*Pounds.*	*Per ct.*	*Per ct.*	*Pounds.*	*Pounds.*	*Per ct.*	*Per ct.*	*Pounds.*	*Pounds.*	*Per ct.*	*Per ct.*
Steel No. 2, 12-inch mortar	Aug. 13, 1896	134	256	51,000	88,750	30.0	48.0	40,208	76,071	21.8	30.2	29,000	67,750	13.2	14.1
Steel No. 1, 12-inch mortar	....do	37	37	44,500	79,000	35.5	56.3	36,860	69,232	24.9	36.8	29,000	62,500	15.0	14.5
Steel No. 2, 12-inch mortar	Sept. —, 1896	28	50	51,500	88,000	28.5	48.6	41,384	77,734	19.6	26.3	29,000	67,500	14.3	18.1
Steel No. 1, 10-inch disappearing	....do	135	197	45,750	83,000	35.5	57.1	34,940	69,246	25.7	36.7	27,000	60,500	15.0	14.8
Steel No. 2, 10-inch disappearing	....do	20	20	45,000	82,500	28.3	51.7	37,560	74,550	23.3	34.6	31,500	70,500	15.8	19.9
Steel No. 1, 10-inch disappearing	Sept. 30, 1896	99	158	46,500	88,500	35.0	53.6	34,100	68,844	25.8	37.9	26,500	61,000	14.0	12.6
Steel No. 2, 10-inch disappearing	....do	21	21	59,500	81,500	27.5	45.1	38,371	74,414	22.0	31.9	29,000	66,500	16.1	18.5
Steel No. 2, 12-inch mortar	Apr. 28, 1897	63	126	47,000	87,000	31.0	48.3	38,861	75,838	22.5	30.8	29,000	66,000	14.5	17.0
Steel No. 1, 12-inch mortar	....do	25	25	42,000	77,000	36.5	57.8	36,040	70,060	27.9	40.9	29,000	62,000	21.5	28.5
Gun levers.															
10-inch disappearing	Sept. —, 1896	17	51	40,000	72,500	35.5	56.8	35,367	66,920	28.9	45.1	29,500	61,250	23.0	38.2
10-inch disappearing	Sept. 30, 1896	16	45	41,000	73,500	33.6	54.9	34,333	67,155	28.8	47.9	27,000	58,500	25.0	39.4

TABLE J.

BRONZE CASTINGS MADE BY CROWN SMELTING COMPANY, CHESTER, PA.

Designation of carriage.	Contract.	Number tested. Pieces.	Number tested. Bars.	Maximum. Elastic limit per square inch.	Maximum. Tensile strength per square inch.	Maximum. Elongation.	Maximum. Contraction of area.	Mean. Elastic limit per square inch.	Mean. Tensile strength per square inch.	Mean. Elongation.	Mean. Contraction of area.	Minimum. Elastic limit per square inch.	Minimum. Tensile strength per square inch.	Minimum. Elongation.	Minimum. Contraction of area.
				Pounds.	*Pounds.*	*Per ct.*	*Per ct.*	*Pounds.*	*Pounds.*	*Per ct.*	*Per ct.*	*Pounds.*	*Pounds.*	*Per ct.*	*Per ct.*
Bronze No. 1, 8-inch disappearing	Jan. 27, 1897	21	21	21,000	49,800	59.0	55.9	18,162	46,600	49.5	46.9	15,000	43,200	23.3	27.2
Bronze No. 3, 8-inch disappearing	do	9	9	22,200	46,000	50.5	47.0	18,388	40,055	28.6	29.8	18,800	37,800	21.5	23.0
Bronze No. 1, 8, 10, and 12 inch breech plates	Feb. 10, 1897	17	17	22,000	50,600	46.5	41.0	20,394	41,741	29.6	29.2	18,000	36,100	19.3	21.9
Bronze No. 3, 8, 10, and 12 inch consoles	do	47	47	20,200	49,800	62.5	61.5	18,910	47,096	42.0	42.0	17,000	41,500	22.2	25.2
Bronze No. 1, 8-inch disappearing	do	14	14	23,500	51,000	59.5	49.2	20,750	41,288	28.7	28.0	18,400	37,000	19.0	17.4
Bronze No. 3, 8-inch disappearing	do	9	9	20,900	51,200	49.0	39.6	19,311	47,600	34.6	34.0	18,600	41,800	21.5	28.2
Bronze No. 1, 10-inch disappearing	Mar. 5, 1897	15	15	20,800	46,200	48.5	41.6	19,986	39,353	28.6	27.6	18,200	30,200	16.2	19.7
Made by Southwark Foundry and Machine Company.															
Bronze No. 1, 10-inch disappearing		2	2	20,600	37,200	28.8	33.0	19,430	37,200	26.4	28.0	18,260	37,200	23.9	23.0
Bronze No. 3, 10-inch disappearing		16	16	36,000	51,300	11.3	18.1	13,600	46,440	7.9	11.8	(*a*)	42,000	5.0	6.6

a Not shown.

GUN IRON MADE BY PHILADELPHIA ROLL AND MACHINE COMPANY, PHILADELPHIA, PA.

12-inch mortar, Southwark	Nov. 20, 1896	69	140	....	37,700	....	....	....	31,235	....	....	....	23,200	....	....
12-inch mortar, azimuth circles	do	21	21	....	36,250	....	....	....	27,731	....	....	....	24,370	....	....

TABLE K.—*Steel forgings made by Benjamin Atha & Illingworth Company, Newark, N. J.*

FORGED STEEL NO. 2—LONGITUDINAL BARS.

Designation of carriage.	Contract.	Number tested.		Maximum.				Mean.				Minimum.			
		Pieces.	Bars.	Elastic limit per square inch.	Tensile strength per square inch.	Elongation.	Contraction of area.	Elastic limit per square inch.	Tensile strength per square inch.	Elongation.	Contraction of area.	Elastic limit per square inch.	Tensile strength per square inch.	Elongation.	Contraction of area.
				Pounds.	*Pounds.*	*Per ct.*	*Per ct.*	*Pounds.*	*Pounds.*	*Per ct.*	*Per ct.*	*Pounds.*	*Pounds.*	*Per ct.*	*Per ct.*
12-inch mortar, Poole	Aug. 13, 1896	51	51	64, 500	102, 500	34. 0	59. 9	46, 890	78, 443	27. 3	44. 8	31, 500	62, 000	17. 0	26. 2
12-inch mortar, Southwark	Sept. —, 1896	18	18	59. 000	93. 500	35. 4	65. 0	49, 688	81, 288	26. 5	45. 8	44, 000	65, 500	16. 0	21. 0
10-inch disappearing, Southwark	.....do	26	26	68, 500	102, 000	33. 4	60. 4	48, 281	82, 538	26. 7	49. 0	39, 500	74, 000	19. 0	31. 8
8-inch disappearing, Niles	Sept. 30, 1896	11	11	65, 000	101, 500	32. 0	61. 1	52, 182	85, 636	26. 6	48. 5	40, 000	74, 000	18. 7	37. 9
12-inch mortar, Poole	Apr. 28, 1897	67	67	53, 500	95, 000	34. 7	59. 4	43, 155	79, 164	28. 4	51. 2	37. 000	70, 500	13. 8	23. 1
12-inch mortar, Providence	May 5, 1897	38	38	62, 000	107, 000	32. 0	59. 9	43, 856	79. 345	28. 9	51. 1	32, 500	69, 500	22. 0	36. 0
FORGED STEEL NO. 3—LONGITUDINAL BARS.															
12-inch mortar, Poole	Aug. 13, 1896	14	14	68, 500	119, 000	25. 2	48. 0	54, 143	101, 214	19. 6	34. 7	40, 500	93, 000	15. 0	20. 0
12-inch mortar, Southwark	Sept. —, 1896	6	6	52, 500	99, 750	25. 9	48. 3	50, 750	95, 867	22. 6	41. 3	50, 000	92, 000	19. 0	34. 7
10-inch disappearing, Southwark	.....do	133	151	77, 000	122, 000	26. 3	60. 9	53, 902	101, 244	20. 3	36. 1	40. 000	90, 500	15. 5	17. 0
10-inch disappearing, Niles	Sept. 30, 1896	45	60	70, 000	112, 500	29. 0	65. 9	63, 550	117, 041	23. 2	41. 1	47, 500	92. 000	15. 4	24. 1
8-inch disappearing, Pond	Jan. —, 1897	72	84	75, 500	116, 500	28. 0	60. 3	53, 650	97, 934	20. 2	36. 2	39, 500	91, 500	15. 0	17. 0
8-inch disappearing, Morgan	Mar. 16, 1897	92	100	81, 500	120, 000	26. 6	59. 4	55, 062	103, 702	19. 9	34. 9	43, 500	91, 000	15. 0	21. 7
12-inch mortar, Poole	Apr. 28, 1897	75	75	59, 500	116, 500	25. 0	44. 3	53, 650	104, 593	19. 2	34. 1	46, 000	90, 000	15. 5	24. 8
12-inch mortar, Providence	May 5, 1897	36	36	62, 500	114, 500	25. 5	51. 4	50, 014	98, 269	21. 2	37. 5	42, 500	89, 500	17. 2	27. 9
FORGED STEEL NO. 3—TRANSVERSE BARS.															
Rollers.															
12-inch mortar, Poole	**Aug. 13, 1896**	**46**	**46**	70, 000	107, 000	22. 5	50. 3	60, 102	100, 250	19. 5	34. 4	51, 000	92, 900	15. 0	21. 0
12-inch mortar, Southwark	**Sept. —, 1896**	**11**	**11**	74, 500	110, 000	20. 0	40. 7	60, 320	101. 591	18. 8	33. 6	51, 500	95. 500	16. 0	26. 8
10-inch disappearing, Southwark	**.....do ......**	**13**	**13**	66, 500	103, 500	24. 0	48. 9	61, 500	95, 040	19. 8	36. 3	51, 500	92, 500	15. 2	24. 1
10-inch disappearing, Niles	**Sept. 30, 1896**	**10**	**10**	71, 500	112, 500	23. 0	44. 3	67, 000	102, 000	19. 3	37. 0	61, 000	95, 500	16. 0	24. 1
8-inch disappearing, Pond	**Jan. —, 1897**	**8**	**8**	76, 000	111, 000	24. 2	41. 0	62, 188	101, 500	20. 4	35. 8	51, 000	93, 500	15. 7	30. 2
8-inch disappearing, Morgan	**Mar. 16, 1897**	**5**	**5**	61, 500	97, 500	22. 2	49. 7	59, 100	95, 400	19. 8	41. 3	56, 500	92, 500	16. 5	26. 8
12-inch mortar, Poole	**Apr. 28, 1897**	**23**	**23**	76, 000	119, 500	25. 0	46. 6	64, 218	104, 543	20. 3	38. 8	51, 500	90, 000	16. 5	22. 4

TABLE L.

FORGINGS MADE BY CAMBRIA IRON COMPANY, JOHNSTOWN, PA.

Designation of carriage.	Number tested.		Maximum.				Mean.				Minimum.			
	Pieces.	Bars.	Elastic limit per square inch.	Tensile strength per square inch.	Elongation.	Contraction of area.	Elastic limit per square inch.	Tensile strength per square inch.	Elongation.	Contraction of area.	Elastic limit per square inch.	Tensile strength per square inch.	Elongation.	Contraction of area.
12-inch Emery carriage forgings.			*Pounds.*	*Pounds.*	*Per cent.*	*Per cent.*	*Pounds.*	*Pounds.*	*Per cent.*	*Per cent.*	*Pounds.*	*Pounds.*	*Per cent.*	*Per cent.*
Open hearth	3	3	40,400	67,600	26.7	47.2	38,270	65,400	24.1	40.2	34,400	63,200	20.0	27.4
Bessemer	3	3	42,100	65,530	31.5	55.1	40,537	62,813	28.3	48.6	38,720	60,450	26.5	39.9

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STATUS OF THE WORK AT THE SOUTHWARK FOUNDRY AND MACHINE COMPANY PHILADELPHIA, PA

TABLE M.—*Ten 12-inch mortar carriages, model 1896.*

Name of part.	Carriage number.									
	58.	59.	60.	61.	62.	63.	64.	65.	66.	67.
Racer										
Base ring										
Top carriage										
Spring box										
Traversing rack										
Elevating rack										
Recoil cylinders										
Azimuth circles										
Removable floor plates										
Guides and caps										
Spring-box brackets										
Spring caps										
Pedestal bracket										
Top carriage fulcrum shaft										
Pistons and rods										
Traversing rollers										
Spring rods										
Shot tongs										
Shot trucks										
Tools										
Bronze parts										

Full black lines show accepted material.

STATUS OF THE WORK AT THE SOUTHWARK FOUNDRY AND MACHINE COMPANY, PHILADELPHIA, PA.

TABLE N.—*Ten 10-inch disappearing carriages, L. F., model 1896.*

Name of part.	Carriage number									
	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
Base ring, right										
Base ring, left										
Racer, right										
Racer, left										
Chassis, right										
Chassis, left										
Top carriage										
Gun lever, right										
Gun lever, left										
Elevating racks										
Elevating band										
Counterweights										
Transoms										
Crosshead clips										
Sight standard										
Elevating arms										
Gun-lever axle										
Suspension rods										
Suspension-rod shaft										
Pistons and rods										
Traversing rollers										
Recoil rollers										
Racer clips										
Distance rings										
Traversing rack										
Ammunition trucks										
Shot tongs										
Bronze parts										
Tools										

Full black lines show accepted material.

Respectfully submitted.

D. A. LYLE,
Captain, Ordnance Department, U. S. A., Inspector.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

(10766—Encs. 2 and 4)

Appendix 27.

PROGRESS REPORT ON THE MANUFACTURE OF STEEL FORGINGS, CASTINGS, ETC., AT THE BETHLEHEM IRON WORKS.

Office of Inspector of Ordnance, U. S. A.,
Bethlehem Iron Works,
South Bethlehem, Pa., August 4, 1897.

Sir: I have the honor to submit the following report of the progress during the fiscal year ending June 30, 1897, of the work ordered by the Ordnance Department to be made under the supervision of the inspector of ordnance at these works.

The Bethlehem Iron Company has been manufacturing forgings and castings under the following contracts or orders, viz:

(1) 21 sets of forgings for 10-inch B. L. R. gun, contract of August 14, 1896.
(2) 22 sets of forgings for 12-inch B. L. R. mortar, contract of August 14, 1896.
(3) 1 set of forgings for 5-inch R. F. gun, contract of September 1, 1896.
(4) 10 sets of forgings for 5-inch B. L. siege gun, contract of December 4, 1896.
(5) 10 sets of forgings for 7-inch B. L. siege howitzer, contract of December 4, 1896.
(6) 36 sets of forgings for 12-inch B. L. R. mortar, contract of May 1, 1897.
(7) 1 set of forgings for 16-inch B. L. R. gun, contract of December 30, 1896.
(8) 10 sets of forgings for 12-inch B. L. R. gun, contract of May 6, 1897.
(9) Miscellaneous forgings for rifles and carriages.

They have also been manufacturing:

(10) One 10-inch disappearing carriage, model 1894, contract of January 8, 1895.
(11) One hundred 8, 10, and 12 inch rifles, contract of November 7, 1891.
(12) Thirty 12-inch B. L. mortars, steel, contract of September 1, 1896.
(13) Twelve 10-inch disappearing carriages, L. F., model 1896, contract of September 1, 1896.
(14) Six 10-inch disappearing carriages, L. F., model 1896, contract of May 24, 1897.

The Carpenter Steel Company have had to furnish the following:

(15) One hundred 12-inch armor-piercing shot, contract of August 7, 1893.
(16) Eighty-one 12-inch armor-piercing shot, contract of December 8, 1894.
(17) Eighty-one 12-inch armor-piercing shot, contract of May 15, 1897.

The trustees of the Brown segmental wire gun have to manufacture:

(18) One 10-inch Brown segmental wire B. L. rifle, contract of December 31, 1896.

(1) FORGINGS FOR 10-INCH B. L. RIFLES.

Twelve sets had been delivered by June 25, 1897, all of them far in advance of the contract times, the last one being delivered over nine months ahead of the specified date of delivery.

(2) FORGINGS FOR 12-INCH B. L. R. MORTARS.

Eleven sets had been delivered by June 25, 1897, and all have been within dates specified by the contract.

(3) FORGINGS FOR 5-INCH RAPID-FIRE GUN.

This set was delivered March 24, 1897.

(4) FORGINGS FOR 5-INCH B. L. SIEGE GUN.

Six sets were delivered by June 12, 1897. Delays were incurred in the first five sets, a total of 208 days.

(5) FORGINGS FOR 7-INCH B. L. SIEGE HOWITZER.

Six sets were delivered by June 12, 1897. The first five sets were delayed a total of 202 days.

(6) FORGINGS FOR 12-INCH B. L. R. MORTAR.

Four sets were delivered by June 29, 1897, all of them within the time allowed.

(7) FORGINGS FOR 16-INCH B. L. R. GUN.

A few small parts for the breech mechanism have been delivered and others are in progress. The mold for the ingot castings for the tube and jacket has just been completed and it is expected that the first ingot will be poured about the last of July.

(8) FORGINGS FOR 12-INCH B. L. R. GUN.

Work has been commenced on this contract and all the pieces of the first set had been forged on June 30, 1897.

(9) MISCELLANEOUS FORGINGS.

The forgings for carriages ordered by the Kilby Manufacturing Company have all been delivered.

The West Point Foundry ordered a main fulcrum shaft and two elevating arms for a Howell disappearing carriage, which have been delivered.

The Niles Tool Works Company ordered sixteen racer clips for 10-inch disappearing carriages, which have been delivered.

The Southwark Foundry and Machine Company ordered ten wormwheel casings, thirty-six half nuts for suspension rods, and sixty traversing rollers, all for 10-inch disappearing carriages. These have all been delivered.

The American Ordnance Company ordered twenty gun shields for field carriages, which were subjected to a ballistic test and have been accepted and delivered.

The Providence Steam Engine Company ordered 618 forgings for the various parts of the 8-inch disappearing carriage, L. F., model 1894. A larger part of these have been accepted and shipped.

Mr. A. H. Emery has ordered a forging for the main press of his 12-inch disappearing carriage. It is now in progress.

From Watertown Arsenal orders for 136 billets for forgings for carriages have been received, and all have been shipped. There has also been ordered, for the hydrostatic test of an 8-inch tube section, two steel hoops, which are in progress.

From Watervliet Arsenal there was ordered a steel tray casting and forged hinge plate for 16-inch B. L. rifle, both of which are in progress. The second locking ring for 5-inch siege gun, referred to in my last annual report, was delivered July 25, 1896, a delay of 27 days.

The following additional forgings were ordered by the Chief of Ordnance:

12-inch D hoop, ordered August 21, 1896, delivered November 24, 1896.
Two 10-inch spindles, ordered March 16, 1897, delivered May 1, 1897.
Two 12-inch compound gears, ordered January 12, 1897, delivered March 27, 1897.

The following forgings have been furnished to replace similar ones found to be defective at Watervliet Arsenal:

5-inch trunnion hoop, delivered September 9, 1896, delayed 70 days.
12-inch breechblock, delivered February 3, 1897, delayed 53 days.

10-inch breechblock, delivered February 17, 1897, delayed 94 days.
12-inch mortar trunnion hoop, delivered May 8, 1897, delayed 45 days.
Ten 5-inch breechblocks, delivered June 28, 1897.

(10) 10-INCH DISAPPEARING CARRIAGE, MODEL 1894.

This carriage, the last one under the contract of January 8, 1895, was delivered August 25, 1896, a delay of 126 days.

(11) 8, 10, AND 12 INCH B. L. STEEL RIFLES.

Up to the date of this report there had been completed twenty-five 8-inch and fifteen 10-inch rifles. There are now in progress ten 10-inch rifles, which are all assembled and for which almost all the parts of the breech mechanism are completed. A few months of work would finish them ready for proof firing. Of the 12-inch rifles four are almost completed excepting the breech mechanisms. Since the latter part of the year 1896 work under this contract has been almost entirely suspended and the plant devoted to the construction of finished mortars.

(12) 12-INCH B. L. MORTARS, STEEL.

Four of these mortars were delivered at Sandy Hook Proving Ground on June 29, two days before the specified time. The next 8 are well under way and will probably be delivered in advance of the time allowed.

(13-14) 10-INCH DISAPPEARING CARRIAGES, L. F., MODEL 1896.

Of the first contract 4 carriages have been delivered, Nos. 19 to 22, inclusive. The delays in presenting each were, No. 19, 31 days; No. 20, 37 days; No. 21, 70 days; No. 22, 72 days. Nearly all the material for the 12 carriages had been made, the exceptions being the chassis for 4 carriages and racers and base rings for 1 carriage. The main parts for 6 carriages were completely machined and awaited assembling.

Of the second contract a few of the minor parts had been forged or cast.

(15-16) 12-INCH ARMOR-PIERCING SHOT.

The projectiles presented under these two contracts having failed to pass the required ballistic test, they were purchased at a reduced price as low-grade shot.

(17) 12-INCH ARMOR-PIERCING SHOT.

This contract was completed on time, the last delivery being made June 29, 1897.

(18) 10-INCH BROWN SEGMENTAL WIRE GUN.

The mill for rolling the staves and the wire-winding machine for this gun have been completed and accepted. The wire is now being manufactured.

The following table of the average physical qualities of specimens tested here during the last year, and representing material which has been accepted, indicates an improvement over the results obtained in the previous two years with gun forgings. The quality of the forgings and castings for gun carriages has been in most cases equal to that

prescribed in Table II of the specifications. The number of specimens tested during the year was 3,917:

Designation of piece.	Number of pieces.	Elastic limit per square inch of original section.	Tensile strength per square inch of original section.	Elongation after rupture.	Reduction in area after rupture.
		Pounds.	*Pounds.*	*Per cent.*	*Per cent.*
5-inch gun body	1	50, 333	81, 333	14. 2	22. 8
5-inch tubes	9	44, 750	87, 811	23. 7	45. 1
5-inch jackets	9	50, 611	92, 281	21. 7	47. 2
5-inch trunnion bands	9	57, 222	103, 217	20. 5	47. 6
5-inch locking rings	2	61, 167	103, 750	20. 8	44. 2
5-inch sleeves	2	55, 250	102, 250	20. 8	38. 4
5-inch breech bushing	1	56, 750	104, 250	19. 9	40. 0
5-inch breechblocks	5	53, 550	97, 333	19. 9	38. 2
5-inch spindles	4	48, 500	88, 500	26. 5	61. 4
5-inch gas-check disks	2	81, 500	151, 250	13. 5	31. 7
5-inch hinge plate	1	55, 000	98, 000	24. 0	56. 0
7-inch howitzer tubes	9	48, 050	88, 340	25. 0	48. 0
7-inch jackets	8	51, 312	96, 290	20. 0	43. 9
7-inch trunnion bands	8	55, 500	100, 900	19. 8	43. 6
7-inch locking ring	1	59, 000	101, 875	22. 2	47. 9
7-inch sleeves	2	59, 000	104, 500	20. 2	41. 7
7-inch breech bushing	1	53, 750	100, 125	21. 5	44. 1
7-inch breechblocks	4	54, 750	97, 900	19. 9	37. 0
7-inch spindles	4	54, 000	92, 125	26. 4	63. 2
7-inch gas-check disks	2	77, 500	152, 250	12. 2	29. 0
10-inch tubes	20	46, 494	88, 222	22. 0	48. 2
10-inch jackets	22	48, 090	90, 695	21. 8	48. 3
10-inch trunnion hoops	31	58, 970	106, 650	16. 6	43. 7
10-inch A hoops	54	58, 100	104, 450	17. 3	46. 4
10-inch B hoops	38	57, 800	103, 990	17. 2	47. 0
10-inch C hoops	33	57, 180	103, 298	18. 6	42. 2
10-inch D hoops	20	57, 133	104, 330	18. 2	43. 9
10-inch breechblocks	12	49, 500	95, 700	18. 8	37. 9
10-inch spindles	25	53, 000	96, 768	19. 8	47. 1
10-inch hinge pins	9	56, 333	108, 444	17. 9	46. 7
10-inch translating rollers	4	53, 750	102, 000	17. 3	38. 9
10-inch securing pins	5	96, 200	161, 680	11. 6	31. 1
10-inch gas-check disks	12	86, 830	152, 600	12. 0	26. 9
10-inch worm shafts	3	57, 330	100, 930	19. 2	48. 1
12-inch A hoop	1	59, 330	106, 267	16. 1	44. 4
12-inch B hoop	1	58. 625	107, 100	14. 7	40. 8
12-inch C hoops	5	57, 200	103, 500	18. 2	42. 5
12-inch D hoop	1	60, 170	103, 200	17. 8	46. 5
12-inch breechblocks	4	49, 750	95, 375	19. 0	42. 9
12-inch spindles	4	51, 000	96, 900	20. 0	47. 3
12-inch hinge pins	4	52, 750	95, 300	21. 4	50. 4
12-inch translating rollers	2	51, 000	95, 250	19. 3	47. 3
12-inch securing pins	2	101, 000	163, 800	18. 7	36. 4
12-inch gas-check cups	3	74, 500	139, 770	12. 3	25. 3
12-inch consoles	10	....	67, 700	25. 0	....
12-inch mortar tubes	41	47, 360	88, 300	21. 8	49. 0
12-inch mortar jackets	44	48, 380	91, 714	21. 2	48. 6
12-inch mortar trunnion hoops	40	60, 708	106, 415	17. 4	45. 1
12-inch mortar A hoops	55	58, 220	104, 850	16. 8	45. 8
12-inch mortar C hoops	46	57, 900	104, 970	17. 7	41. 0
12-inch mortar D hoops	15	59, 444	105, 760	16. 3	44. 1
12-inch mortar breech bushing	10	57, 700	101, 760	18. 4	40. 6
12-inch mortar breechblocks	27	51, 300	95, 780	19. 3	42. 2
12-inch mortar spindles	31	54, 200	95, 500	20. 0	45. 5
12-inch mortar hinge pins	17	55, 200	102, 350	19. 1	47. 1
12-inch mortar translating rollers	17	55, 650	100, 350	20. 6	51. 6
12-inch mortar gas-check disks	12	82, 870	141, 944	11. 8	27. 7
12-inch mortar consoles	30	....	70, 870	36. 1	....
Forged steel No. 1	3	....	66, 833	31. 7	60. 8
Forged steel No. 2	28	....	80, 948	26. 5	49. 9
Forged steel No. 3	291	....	101, 616	19. 5	36. 2
Cast steel No. 1	76	....	68, 896	29. 1	48. 1
Cast steel No. 2	6	....	72, 750	26. 7	42. 5
Cast iron No. 1	2	....	19, 450	....	....
Gun iron	49	....	33, 079	....	....
Bronze No. 1	23	....	43, 687	....	....
Bronze No. 2	11	....	47, 800	....	....
8-inch cast-iron shot	4	....	31, 250	....	....
10-inch cast-iron shot	1	....	30, 900	....	....

The shipments made during the year are as follows:

Number.	Articles.	Weight.
		Pounds.
15	8-inch B. L. steel rifles	479, 506
14	10-inch B. L. steel rifles	942, 787
4	12-inch B. L. rifled mortars, steel	115, 908
5	10-inch disappearing carriages	965, 446
94	Forgings for 5-inch B. L. siege guns	61, 188
90	Forgings for 7-inch B. L. siege howitzers	39, 624
353	Forgings for 10-inch B. L. rifled guns	1, 055, 606
4	Forgings for 12-inch B. L. rifles	13, 564
302	Forgings for 12-inch B. L. rifled mortars	505, 298
2	Forgings for 16-inch B. L. rifled gun	109
919	Miscellaneous forgings	355, 835
	Total	4, 534, 871

Very respectfully, your obedient servant,

I. MACNUTT,
Captain, Ordnance Department, U. S. A., Inspector.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

(10915—Enc. 2)

APPENDIX 28.

PROGRESS REPORT AT THE WORKS OF ROBERT POOLE & SON COMPANY, JUNE 30, 1897.

OFFICE OF INSPECTOR OF ORDNANCE, U. S. A.,
WORKS OF ROBERT POOLE & SON CO.,
Baltimore, Md., July 20, 1897.

SIR: I have the honor to submit a report on the progress of work here up to June 30, 1897.

On August 17, 1896, a contract was made with Robert Poole & Son Company, of Baltimore, Md., for furnishing fifty-seven 12-inch mortar carriages, model 1896. The first delivery was to be made ten weeks from above date, and thereafter at the rate of four carriages per month. This would require the thirty-third carriage to be delivered at the end of June, 1897. Actually 35 have been completed and shipped.

Nothing out of the ordinary has been experienced. The main difficulties, which were soon overcome, lay with points incidental to new work, changes in drawings, and subsequently, for a short time, in getting suitable rollers and recoil cylinders. The methods employed by the company formed the subject of a report on a closely allied carriage, made here in 1893 and 1894, and have not been changed. As fast as each carriage has been completed, special reports on its maneuvers, as well as on the material employed, have been forwarded.

A description of the carriage, with method of assembling, etc., formed the subject of a separate note sent you April 26, 1897. It is therefore considered unnecessary to repeat them here.

The shipments have been as follows:

Carriages Nos. 1 to 12, inclusive, to Fort Monroe, Va.
Carriages Nos. 13 and 15 to 29, inclusive, to Fort Adams, R. I.
Carriage No. 14 to Sandy Hook Proving Ground, N. J.
Carriages Nos. 30, 31, 32, and 33 to Fort Preble, Me.
Carriage No. 34 to North Point, Baltimore, Md.
Carriage No. 35 to Fort Point, Galveston, Tex.

This contract expires on December 26, 1897, and from the present outlook there appears to be no reason to suppose it will be delayed beyond that date.

Another contract, dated April 28, 1897, calls for 35 more carriages of the same model. The first carriage must be furnished on or before July 31, and thereafter deliveries are to begin in October and continue at the rate of 5 per month until end of April, 1898, when the contract expires.

The gun iron castings for the base ring, racer, and top carriage were furnished by the company. Excepting bronze, the rest of the material was furnished by Benj. Atha & Illingworth Company, Newark, N. J.; Penn Iron Company, Lancaster, Pa.; Penn Steel Casting Company, Chester, Pa., and Charles Scott Spring Company, Philadelphia, Pa.

The inspection of this material for physical qualities was made by Capt. D. A. Lyle, Ordnance Department, and the tests it has been subjected to have been reported by him.

Respectfully,

H. D. BORUP,
Captain, Ordnance Department, U. S. A.

The CHIEF OF ORDNANCE, U. S. ARMY,
Washington, D. C.

(16777—Encs. 562 and 563)

APPENDIX 29.

PROGRESS REPORT OF THE MANUFACTURE OF 10-INCH DISAPPEARING GUN CARRIAGES, BY THE KILBY MANUFACTURING COMPANY, OF CLEVELAND, OHIO; OF 10-INCH DISAPPEARING GUN CARRIAGES, AND FINISHING AND ASSEMBLING 12-INCH B. L. STEEL MORTARS, AT THE NILES TOOL WORKS COMPANY, OF HAMILTON, OHIO; OF 8-INCH DISAPPEARING GUN CARRIAGES, BY THE MORGAN ENGINEERING COMPANY, OF ALLIANCE, OHIO, ETC.

OFFICE OF INSPECTOR OF ORDNANCE, U. S. A.,
Cleveland, Ohio, August 21, 1897.

SIR: I have the honor to make the following report of the progress of the contracts under my supervision for the year 1896–97:

Contract of Kilby Manufacturing Company, Cleveland, Ohio, dated December 20, 1894, for ten 10-inch disappearing carriages, L. F., model 1894. Nine carriages have been completed. The tenth carriage is nearly assembled, and the contract will be completed by September 1, 1897.

Contracts of the Niles Tool Works Company, Hamilton, Ohio. First contract dated August 17, 1896, for eight 10-inch disappearing carriages, L. F., model 1896. Two carriages have been delivered and shipped; a third carriage is ready for shop trial. The state of progress of the contract is shown by the accompanying diagram.

Second contract, dated May 5, 1897, for six 10-inch disappearing carriages, L. F., model 1896. Two chassis rails have been cast, but not yet tested, and a lot of bronze fittings and small steel parts made, but not yet machined.

Third contract, dated May 5, 1897, for assembling fifteen 12-inch B. L. steel mortars. There has been some delay in receipt of forgings. The present state of the contract is indicated in the accompanying diagram. The machining of parts has begun.

Contract of the Morgan Engineering Company, Alliance, Ohio, dated December 26, 1896, for nine 8-inch disappearing carriages, L. F., model 1894. Three carriages have been delivered and considerable progress has been made on the others. The contractors will complete their contract about December 1, 1897. The present state of progress is shown by the accompanying diagram.

MISCELLANEOUS CONTRACTS.

American Hoist and Derrick Company, St. Paul, Minn. Contract for fifteen 12-inch mortar carriages. (Pratt & Letchworth Company, Buffalo, N. Y., contractors for furnishing steel castings.)

The following steel castings were ordered by the contractors from the Pratt & Letchworth Company:

Brackets for hydraulic cylinders	60
Distance pieces for azimuth circles	120
Guides	60
Caps	30
Hydraulic cylinders	30

Caps for springs	15
Washers for spring rods (hexagonal)	75
Washers for spring rods (cylindrical)	75
Elevating racks	15
Steel wrench nuts	15
Friction cones	15
Caster brackets	60
Box wrenches	15

The following castings have been thus far accepted:

Guides	32
Brackets for hydraulic cylinders	58
Caps	30
Distance pieces for azimuth circles	80
Cap for springs	1
Washers	48
Friction cones	14
Steel hand nuts	3
Elevating racks	7
Caster brackets	59
Box wrenches	13
Hydraulic cylinders	4

Nearly all the remaining parts have been cast, and the order will be completed in all probability before September 30.

Contract of R. J. Gatling, dated August 7, 1896, for furnishing one 8-inch caliber high-power gun cast in one piece.

The Otis Steel Company, Cleveland, Ohio, are contractors for furnishing the casting for the experimental gun and the machinery and labor for forging it.

This machinery was built at the works of the Kilby Manufacturing Company, Cleveland, Ohio, and is completed except the bar or screw carrying the forging head.

The foundations for the forging machinery and the furnace for heating casting at the Otis Steel Works have been completed. A detailed description of the manufacture will be furnished as soon as the work is completed.

The casting for the gun has been made and, so far as can be judged, is sound.

Contract of A. H. Emery, Stamford, Conn., for furnishing one 12-inch elevating gun carriage, dated March 17, 1893.

The following parts have been received at the Niles Tool Works, contractors for Mr. Emery, and partly machined: One steel curb made of parts 2 and 24, and the plates riveted thereto with its lower head; one spring cylinder consisting of three parts, 14 A, 14 B, 14 C, gun iron; one bed plate, 7 and 7 A, gun iron; one cylinder bed plate, No. 8; one steel ring, No. 18; one steel ring, No. 168; one steel link casting, No. 51; one steel link casting, No. 52; one steel yoke beam, No. 48; one steel saddle, No. 68; one steel carriage body, No. 67; eight steel disks, Nos. 12, 18, 19, 20, 21, 35, 35, and 86; two caps, No. 60; one cap each Nos. 69, 490, and 491; two caps, No. 58; one cap, No. 61.

The following bronze castings were made by the Niles Tool Works: 4 pieces No. 471 bushing, 6 pieces No. 422 bushing, 2 pieces No. 473 bushing, 1 piece No. 474 bushing, 2 pieces No. 475 bushing, 2 pieces No. 476 bushing, 4 pieces No. 477 bushing.

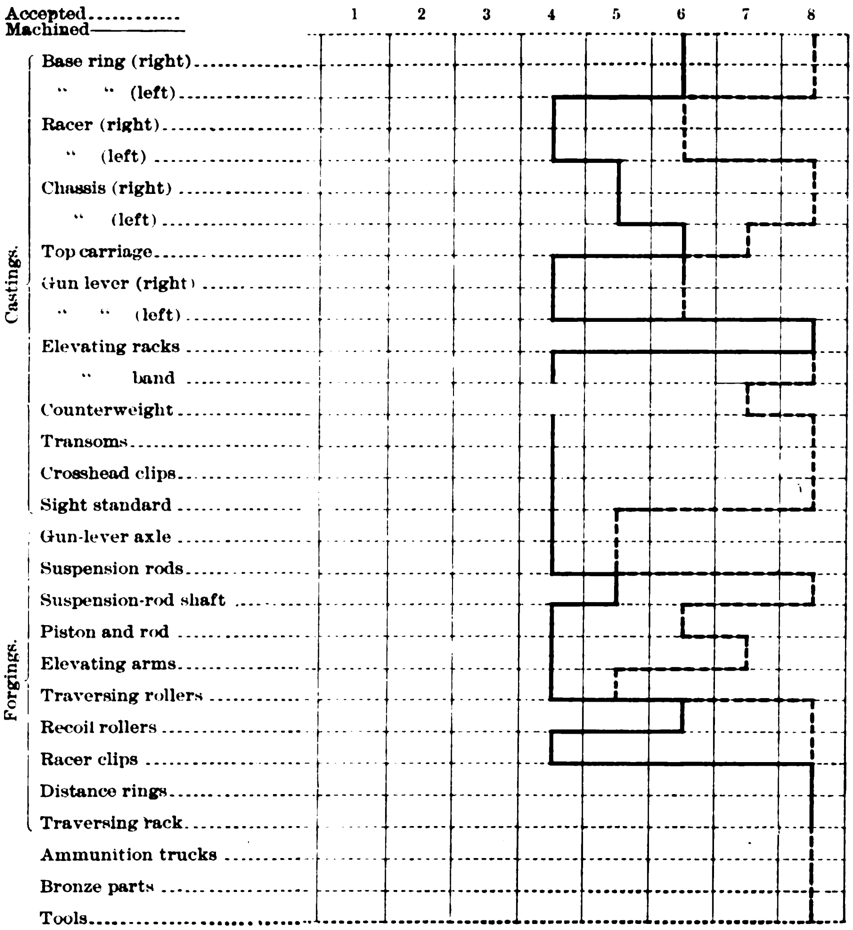
Very respectfully,
W. W. Gibson,
Captain, Ordnance Department, U. S. A., Inspector.

The Chief of Ordnance, U. S. Army,
Washington, D. C.

(22696)

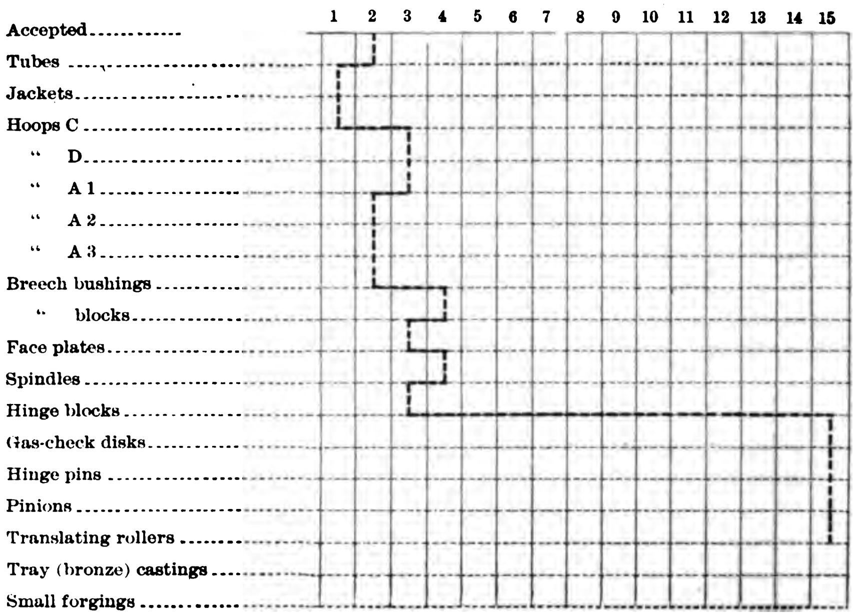
NILES TOOL WORKS CO.

Contract of August 17, 1896, for eight 10-inch disappearing gun carriages, L. F., Model 1896.



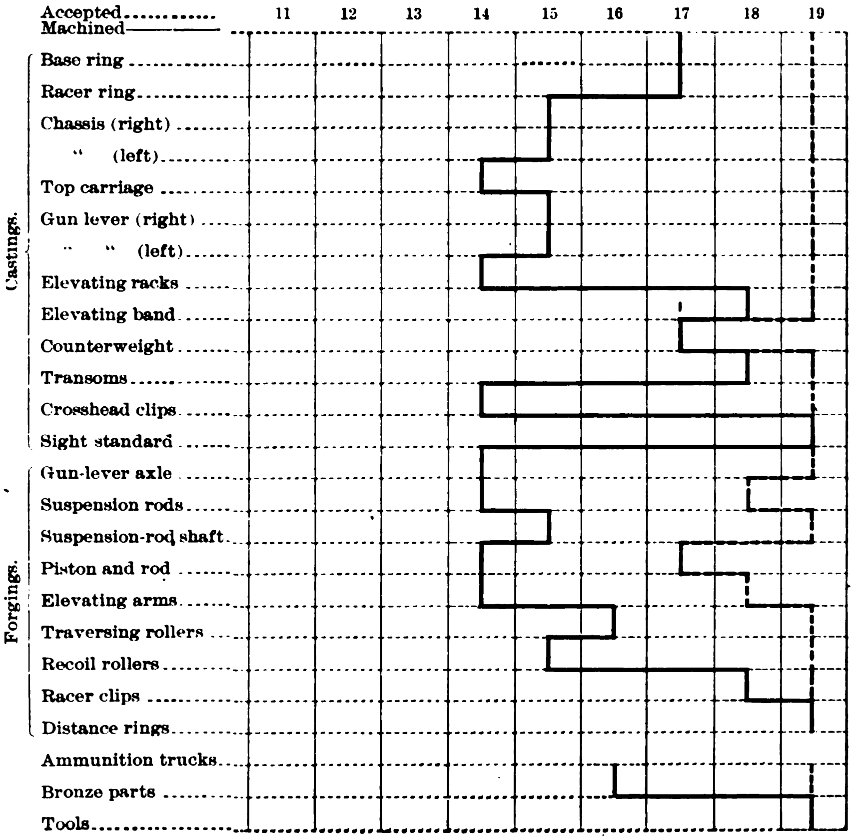
NILES TOOL WORKS CO.

Contract of May 5, 1897, for finishing and assembling fifteen 12-inch B. L. R. Mortars (steel), Model 1890 M1.



MORGAN ENGINEERING CO.

Contract of December 26, 1896, for nine 8-inch disappearing gun carriages, L. F., Model 1894.



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